LAC CULTIVATION IN INDIA

Being a Second and revised edition of "A Practical Manual of Lac Cultivation" by P. M. Glover, published in June 1931.

By

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ERRATA

Illustrations	Line 34 for 'attached' read 'attacked'
Page 2, para 5	Line 2 for 'Rhyncota' read 'Rhynchota'
Page 14, para 1	Line 1 for 'Rajnadgaon' read 'Rajnandgaon'
Page 14, Table IV	No. 10 for 'Dhamtara' read 'Dhamtari'
Page 22	The words 'Very Scarce' refer to Kusum brood June-July 1937,
Page 53, para 5	Line 1 for 'lact' read 'lac'
Page 83, para 3	Line 1 for 'last' read 'lac'
Page 96 and 99	For *'Engelhartia'* read *'Engelhardtia'*
Page 118, para 2	'Cynogas' is now marketed as 'Cymag'
Page 124, para 1	For 'la' and 'lb' read 'a' and 'b'
Page 129, para 5	Line 4 for 'creditable' read 'credible'
Page 136	Line 24 for 'Pauk-nwe' read 'Petwun'
Page 143	Line 22 for 'this' read 'thin'

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PREFACE TO THE FIRST EDITION.

This pamphlet was originally intended as an answer to the very numerous letters received at this Institute, asking for information and advice regarding the cultivation of Lac. For this reason the major portion of it has been given over to the practical side of the question, and an attempt has been made to produce a pamphlet which explains as clearly as possible, the practical process of Lac Cultivation from the very beginning. Morphological description of *Laccifer lacca* has therefore been omitted, excellent accounts however may be had in many of the works quoted in the Bibliography, particularly Negi (1929).

Later it was decided that its value would be much increased if it were expanded to include some of the important practical research results obtained at this Institute. Also since the ravages of pests are such an important factor in Lac Cultivation, a short explanation of their method of attack has been included in order to elucidate the control methods which are suggested.

The chapters recounting the various methods of dealing with the several host trees, have been written with particular reference to Bihar & Orissa, and for other districts may require slight modifications, they apply however over a very large percentage of lac growing districts but do not include Assam and Burma.

My thanks are due to Mrs. Dorothy Norris, Director of this Institute for very valuable advice and criticism, and for much of the information regarding lac cultivation in Assam and the Central Provinces, to Mr. H. T. Bates, Manager, Sabaya Division, Assam Frontier Tea Company, Ltd., for valuable criticism and advice, to Dr. C.F.C. Beeson, Forest Entomologist, Dehra Dun for advice and criticism more particularly of the Entomological chapters, and to Mr. E. Benskin, Conservator of Forests, Bihar and Orissa, for arranging a tour for me round a number of the Lac Plantations and Orchards under his charge. Also to the members of the Institute staff, for the loan of photographs, and other practical help, particularly, to Mr. Negi, the Assistant Entomologist who supplied me with data for the paragraphs on forecast of swarming date and to Mr. Heber, the Artist and Photographer, who took many of the photographs, developed and printed those taken by myself, and prepared the diagrams and coloured plate for me.

Dated Namkum, June, 1931.

P. M. GLOVER.

PREFACE TO THE SECOND EDITION.

The first edition of this book was published in 1931. Since then conditions affecting the lac industry have changed very considerably and much that occurs in the original edition is now out of date, particularly the sections referring to the plantation growth of lac.

During the past six years a great deal work has been done at the Indian Lac Research Institute, and as result much information of practical value to the cultivator has been obtained, and is incorporated in this book, the scope of which has been widened to include matter likely to be of interest to the educated cultivator.

The illustrations with a few exceptions are entirely new.

My thanks are due to Sir Bryce Burt, President of the Indian Lac Cess Committee, Mr. A. P. Middleton, I.C.S., Commissioner of Chota Nagpur and member of the India Lac Cess Committee and to Dr. H. K. Sen, Director of the Indian Lac Research Institute for valuable advice and criticism; to Dr. J. C. M. Gardiner Systematic Entomologist Forest Research Institute, Dehra Dun for advice more particularly in respect of the Entomological chapters, to Mr. H. Bates, Manager Palandu Division, Assam Frontier Tea Company for much practical criticism, and to the Forest Department, Bihar, particularly the Conservator of Forests, Mr. Owden for advice and facilities for experiment in the lac plantations under his charge.

I should also like to thank members of the Institute staff for their help, particularly Mr. Heber, the artist and photographer, who preparated the plates and some of the photographs.

Other acknowledgments are made in the text.

Dated Namkum, 1937. P. M. GLOVER.

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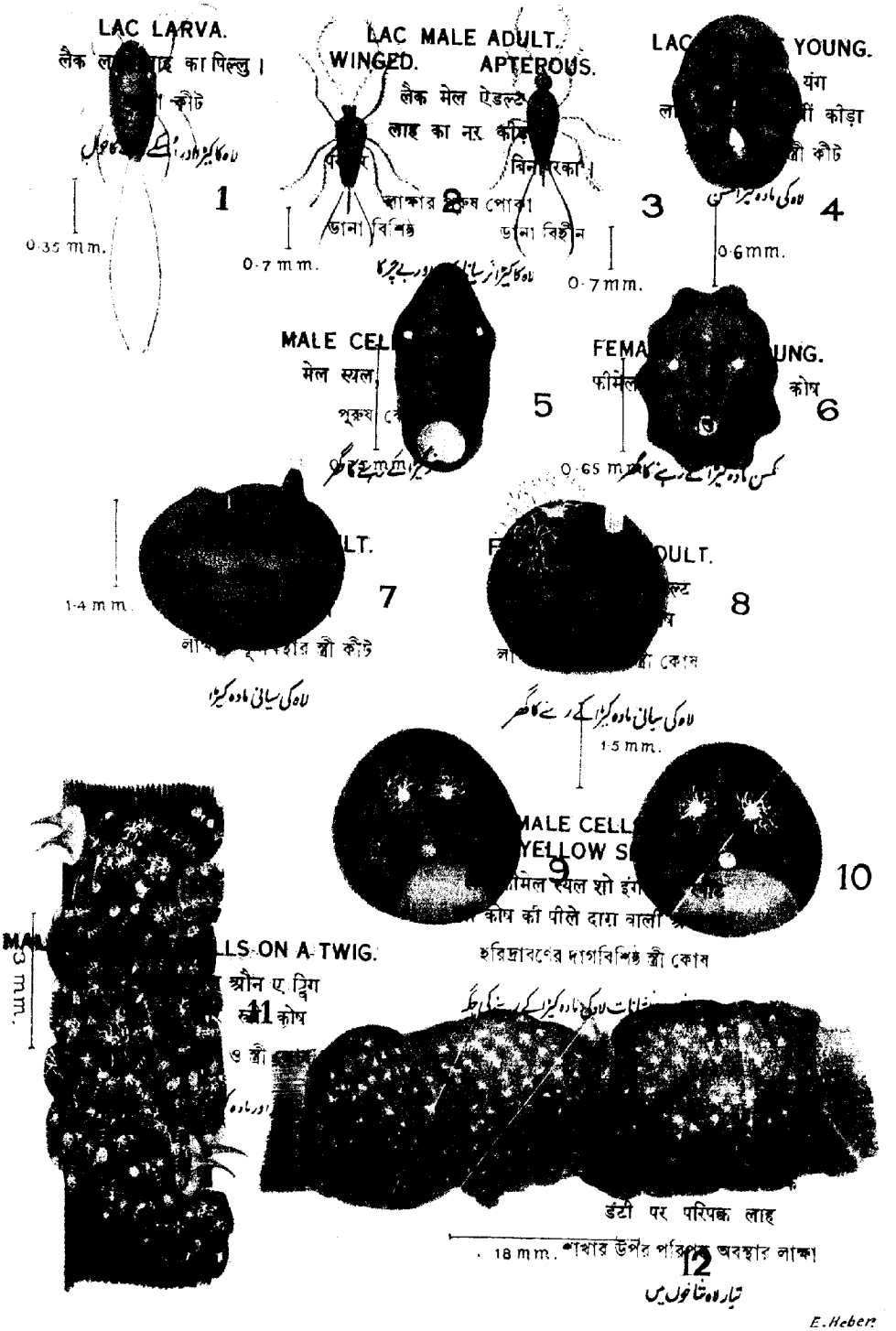
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COLOURED PLATE I

EXPLANATION

1. Lac larvae.
2. Lac male, adult, winged.
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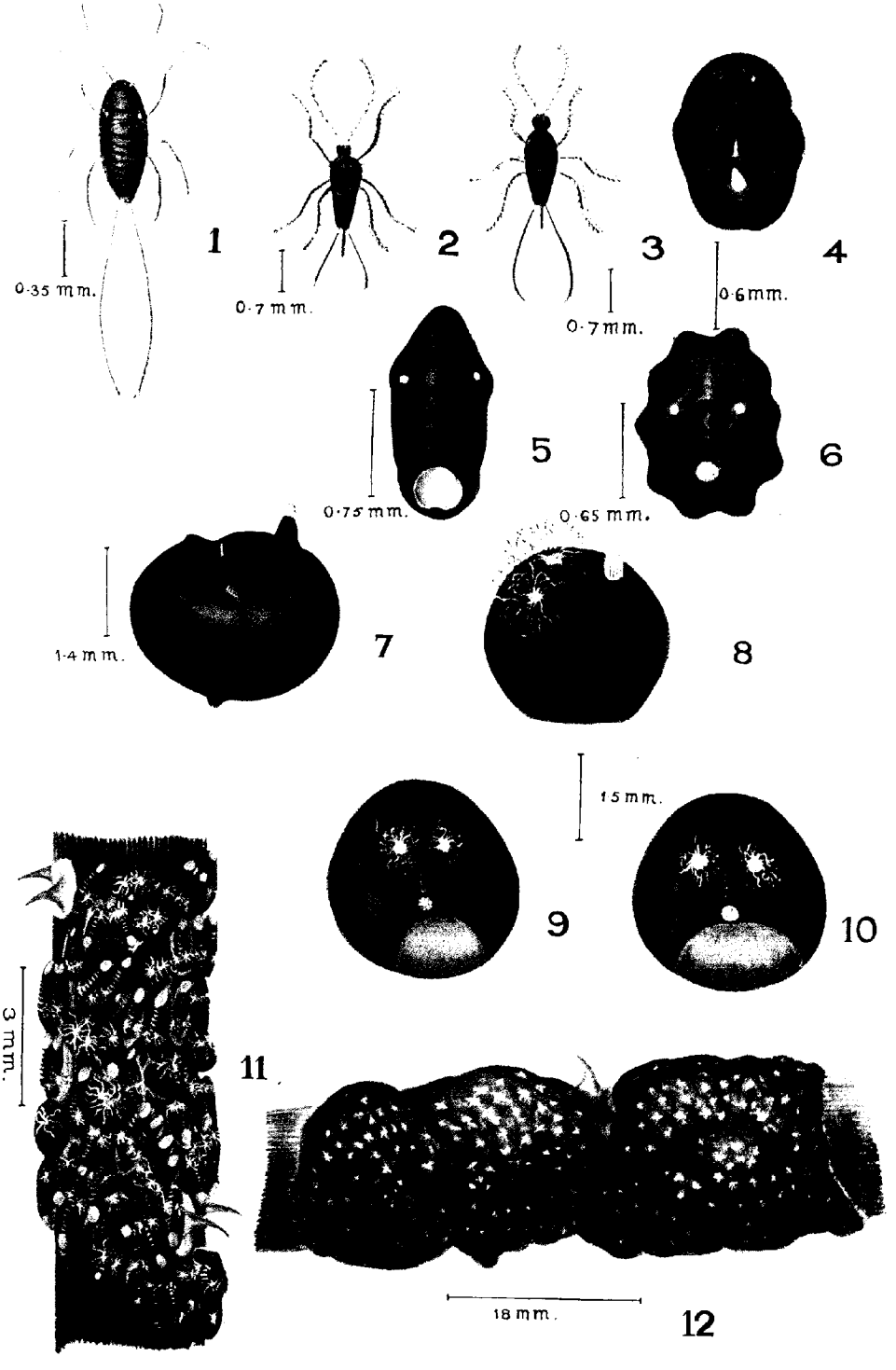
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E. Heber.

THE
INDIAN LAC RESEARCH INSTITUTE

CHAPTER I.

INTRODUCTION AND GENERAL ACCOUNT OF THE LAC INSECT AND THE LAC CROPS.

Introduction.

Data on which the book is based.

Articles on lac cultivation are frequently to be seen in journals published in India and occasionally in journals published elsewhere. Some of these articles are of real interest, but many others are based on theoretical or at the best slight practical knowledge only. In other instances the articles are based on experience gained in some particular district, usually outside the major area of lac cultivation, or on results obtained from a few hosts only, often in some particular season, and are not generally applicable. Results thus obtained are seldom of more than restricted use and often lead to a misinterpretation of the true facts.

In this book methods of lac cultivation are explained based on a long period of practical experiment on large numbers of lac hosts of different species, not only at Namkum, but also in the experimental plantations in various districts throughout the major lac growing area, working in co-operation with the Indian Lac Research Institute. Full use also has been made of the Institute's voluminous correspondence with lac growers throughout India.

Application of this book.

Certain chapters e.g. Chapters II to IV and XXII apply more particularly to large scale cultivation or are theoretical and are intended more particularly for the use of Forest Officers, Zamindars, and Officers in Indian States. Other chapters especially those concerned with pruning, infection, cropping, use of various hosts, pest control etc. apply to all types of cultivation whether by Raiyat, Landowner or Forest Officer.

The intelligent use of the methods here described will help the cultivator to obtain the greatest possible return of healthy high grade, pest free lac, with the minimum possible expenditure.

It should be added that though this book is written mainly for the major area of lac cultivation (Chota Nagpur in Bihar, which produces more than half the lac grown in India) the general principles of cultivation such as pruning

infection, crop reaping, and control of insect pests, forecast of swarming etc. are of general application wherever lac is grown. Chapters XV to XVIII contain information as regards lac cultivation in other areas of importance.

Value of Bihar Forest Department lac plantations.

Mention should be made of the great value of the Bihar Forest Department lac plantations to the Indian Lac Research Institute. Of these plantations the more important are Kundri, Mako, and Betla in Palamau; Pelwal and Horhap in Ranchi District; and Bichagutu in Singbhum. Without the facility to experiment in, and inspect these plantations much of this book would have local application to Namkum and the immediate surrounding Ranchi District alone. Full use has been made of them and in many instances, the conclusions formed at Namkum based on lac cultivation in a manured and cultivated area in the moderate climate of Ranchi District have had to be modified after experiment under more arid conditions and in plantations where manuring and cultivation are not carried out, whilst other results have been confirmed.

Further they are of immeasurable value in that results obtained at Namkum can be tested out on a large scale, under conditions far closer to those of raiyat cultivation than at Namkum, as for example highly experienced labour is not available.

These plantations are now forming important centres in which biological control work can be initiated, and tested.

Lac is a resinous substance secreted by an insect known as the lac insect which is a member of the Order *Hemiptera* (*Rhyncota*) and of the super family *Coccidae* which is comprised of the Scale insects and Mealy bugs.

Allied species.

The super family *Coccidae* contains a number of extremely injurious species, examples are the San Jose scale, *Aspidiotus perniciosus,* the cottony cushion scale, *Icerya purchasi,* the Californian red scale *Chrysomphalus aurantii,* and many more. It contains also such useful species as the lac insect *Laccifer lacca* and the cochineal insect *Dactylopius coccus.* The dye stuff known as Kermes or *granum tinctorium* is prepared from the dried females of *Kermes ilicis.* Several *Coccids* yield wax in sufficient quantities to be used commercially notably the Chinese wax insect *Ericerus pe-la* and a species of *Ceroplastes* in India *C. ceriferus.* The gum lac insect *Gascardia* of Madagascar is not a near relative of the lac insect, the secretion produced has a much higher percentage of wax in it than has lac, according to MacGillivray (1921) this insect is really a species of *Ceroplastes.*

Early accounts of the Lac Insect.

In 1709 Father Tachard published an account of the insect which produces lac, noteworthy for its careful and accurate observations. In 1782 Kerr wrote a brief description of the lac insect, which he termed *Coccus lacca.* Numerous further descriptions have since been published, among the earlier of these are the accounts by Ratzeburg (1833) and by Carter (1861), the latter of particular

interest, both of whom refer to the insect as *Coccus lacca*. More recent descriptions include those of Green (1922) in his *"Coccidae of Ceylon"* and of Imms and Chatterjee (1915), who describe the lac insect under the name *Tachardia lacca* Kerr, the type species of the Genus *Tachardia* to which it was at that time generally relegated. Chamberlin (1923), an authority on the *Tachardiinae* redescribed *Tachardia lacca* in his monograph of the *Tachardiinae* or lac insects in the Bulletin of Entomological Research. In the Supplement to his monograph published in the same Journal in 1925 he points out that Cockerell has drawn attention to the fact that *Coccus lacca* the type of the Genus *Tachardia* was used by Oken as early as 1815 in establishing his Genus *Laccifer* and hence the latter name takes precedence. According to the International Rules of Nomenclature this change has to be made although in this instance it is particularly unfortunate. The correct designation of the lac insect is therefore *Laccifer lacca,* Kerr. and it is referable to the family *Lacciferidæ,* Cockerell.

Among important works on the lac insect and lac cultivation, those of Stebbing (1910), Imms and Chatterjee (1915), Lindsay and Harlow (1921), Lyall (1928) and C. S. Misra (1928) must also be mentioned.

Geographical Range of the Family Lacciferidæ.

L. lacca falls into the Family *Lacciferidæ*. The geographical range of the Family is very wide, and species have been recorded from all Continents except Europe. Chamberlin (1923) records species in North and South America, from the South Western United States, Mexico and Jamaica, British Guiana, Brazil and Argentina. In Australia it occurs over wide areas, in Asia from Formosa, Burma, Philippines, India and Nepal; from Ceylon and Java, and in Africa from Uganda. The actual range of the Family is probably much greater. Six Genera occur of which all the species except those of the Genus *Tachardina* secrete a true lac, it is only however from the species of the Genus *Laccifer* that it has been found possible to recover it. Other Genera are *Metatachardia, Tachardiella, Austrotachardia* and *Afrotachardia.* Species of the Genus *Laccifer* occur in India, Assam, Burma, Ceylon, Java, Federated Malay States, China, Indo-China and Siam. A number of species are known, of these however *Laccifer lacca* is by far the most important and produces the bulk of the lac of commerce. Many of the species of the Genus *Laccifer* which have been designated are almost certainly strains or at the most varieties of *Laccifer lacca. L. lacca* occurs in India and strains occur in Burma and Assam. (*Cf.* Chapter XXII).

Species of Laccifer.

Importance of the Shellac Trade to India.

The production of lac is virtually a monopoly in the hands of India and Burma, and the Shellac Trade is of the greatest importance to India.

The Lac and Shellac industry provides employment and livelihood for a very considerable number of people, from the Shipper, Broker, Middleman, and Manufacturer to the Raiyat who cultivates lac, the raw material from which shellac is manufactured. The industry is of particular importance to Bihar where the greater part of the lac produced in India is grown and where much

of it is manufactured, in many districts of which the raiyat is dependant on the returns from his lac cultivation for everything over and above mere existence.

Production of Lac ex India.

Outside India lac is grown in small amounts in Ceylon, Java, the Federated Malay States, China, Indo-China, Borneo and Siam. Much of this lac finds its way into Calcutta via Bangkok and Singapore, where it is manufactured into Shellac.

The Lac Insect and Lac hosts.

The lac insect which secretes the resinous substance lac as a protective covering is theoretically at least an injurious insect cultivated on account of the commercial value of its protective secretion. It spends its life on certain trees, shrubs and creepers, which are known for this reason as lac hosts, feeding upon their sap juices. The protective secretion is manufactured by the insect from the sap juices of the trees on which it is parasitic and which are sucked into the alimentary canal by way of the specialised mouths parts, the proboscis.

Lac Larvæ.

The insect starts its life as a minute boat-shaped red coloured larva a little over half a millimeter in length. The larvæ emerge at certain times of year in large numbers from the cells of the female lac insects in mature lac, are active and capable of crawling a considerable distance. This emergence of larvæ is known as swarming and as many as 1,000 larvæ may emerge from the body of a single female, the average number, lies between 200—500. They are insect-like in appearance, the first or head segment bears the antennæ and the ocellanæ or simple eyes ; the thorax is three segmented, each segment bears a pair of walking legs, the thorax also has two pairs of spiracles (breathing pores). The abdomen bears terminally a pair of long setæ, the caudal setæ. The mouth parts are ventral in position and consist in two pairs of setæ which represent respectively the specialised mandibles and maxillæ which together form a sucking tube the proboscis.

Pruning.

The larvæ prefer young and succulent shoots on which to settle and feed and choose particularly the under sides of such twigs. They are unable to settle and feed on old hard shoots and it is, therefore, the practice to prune trees to be used as lac hosts sometime prior to utilising them, to ensure the maximum number of shoots in optimum condition for colonisation by the lac larvæ. Unpruned trees can, however, be utilised as lac hosts but do not yield the maximum crop possible.

Infection

The larvæ are introduced to their new host by a process which is known as infection or inoculation, which consists in cutting branches bearing mature lac, from which the larvæ are about to emerge, into pieces of convenient length generally about 9″ to 1′. Lac in this condition is known as "brood" lac because it contains the young swarm. These brood sticks are then tied to the host tree on which it is proposed to raise a lac crop, they may be tied singly, in bundles of 3-4 or more, to the host tree, or even simply interlaced among the host branches.

PLATE I.

Immature lac on *Zizyphus Jujuba* (Ber) showing male and female cells.

Larval Settlement.

The larvæ emerge in enormous numbers from the brood and crawl on to the branches of the host tree where after some time, they come to settle on the shoots which have resulted from previous pruning. Here they settle, the legs and antennæ beneath the boat-shaped body, and force their mouth parts through the bark into the phloem and xylem tissues and start to feed on the sap juices of the host.

The larval settlement is very dense, often completely covering the lower surface of the twigs and even extending onto the upper surface, one larva being very close to and possibly touching the next. The settlement is in the neighbourhood of 150—200 larvæ per linear 1".

Lac Secretion.

Secretion of lac begins almost immediately, appearing at first as a shining layer over the bodies of the settled larvæ. The secretion is produced by glands in the insect body. The secretion remains and partially hardens forming a coating over the insect bodies. The lac larvæ grow inside this coating and undergo morphological changes and lac secretion continues, so that the coating of lac over their bodies is added to from the inside thus forming a more or less globular cell or test which is continually added to during the period of lac secretion. As secretion continues the coating round one insect meets and coalesces with that from another and in this way a continuous or semi-continuous covering or encrustation is formed.

Male and Female Cells.

The larvæ which settle although extremely similar are actually separable by minute and not well defined differences under a low power microscope by an experienced worker, into males and females. The percentages of males and females varies from year to year and crop to crop, but approximates to 30% males to 70% females.

The cells produced by male and female larvæ differ in shape and can easily be distinguished after some time. The male cell is elongate, roughly cigar shaped, the anterior brachial pores (through which respiration occurs) are towards the anterior end ; and posteriorly in the fully formed cell is a large circular opening covered by a flap or operculum via which the male insect eventually emerges.

The female cell is smaller and in general shape oval, towards the anterior end lie the anterior brachial pores, posteriorly there is a single small opening, the anal tubercular opening ; longitudinally a mid dorsal ridge indicates the position of the cast larval skin.

White Filaments.

Through these three openings of the lac cell, the brachial pores and the anal tubercular pore, waxy white filaments protrude, and may be so numerous as to give the whole encrustation a woolly white appearance. They are produced by glands in the insect body and their presence is an indication that the insects are alive and healthy. Their function is mechanical, ensuring

that these essential openings in the lac cell are not blocked during lac secretion. Their absence does not necessarily denote unhealthy lac as healthy lac may frequently be seen devoid of filaments or with very short filaments only, these having been blown away by wind or broken off by insects crawling over the lac encrustation. These filaments are not, as has at times been stated, connected with respiration.

Emergence of Males.

The male larva moults within the cell attains the second stage and after a while passes through a pseudo-prepupal stage and becomes a pseudo-pupa. Finally the adult male emerges from the pseudo-pupa and leaves the cell by pushing open the operculum and emerging backwards to the outside. The male is much larger than the larva and red coloured. The head bears the antennæ and a pair of eyes, mouth parts are absent and the adult male, therefore, is unable to feed. The thorax bears three pairs of legs, and there may or may not be a pair of hyaline wings, if wings are absent the male is known as apterous. The abdomen bears apically a prominent genital sheath containing the penis. At either side of the genital sheath arises a long white setæ, the caudal setæ, these setæ, are easily broken off.

Male Insect.

Fertilisation.

The males walk over the lac encrustation fertilising the female insects within their cells by way of the anal tubercular openings, each male being capable of fertilising several females. The life of the males is brief, and having performed the function of fertilisation, they die.

At this stage the cells of both sexes are small, that of the male is larger than that of the female, but is very thin walled, actually the lac produced by the males is so small as to be of no commercial value. Practically the whole of the secretion of lac occurs after the males have emerged. When the males have emerged, the encrustation is made up entirely of females cells and empty male cells.

Excess of Males.

Sometimes, particularly in the Baisakhi crop, males are present in excess of 30%, and certain branches may be colonised entirely by male cells, thus after male emergence these branches may be found covered with empty cigar shaped cells which often gives the impression that the lac is dead whereas in reality it merely represents excessive numbers of cells from which the males have emerged. Excess of males is detrimental to the cultivator.

Parthenogenesis.

It has been shown at Namkum that in the life cycle of the lac insect, full development of the female and the production of young can occur without any intervention on the part of the male. This form of asexual reproduction is known as parthenogenesis. The progeny of a strain from which the males were eliminated during the Katki 1929 crop is still continuing, in each generation a normal progeny of male and female young has been produced, and in each case the males have been eliminated. This parthenogenetic strain has now been bred to the 15th asexually produced generation, and a

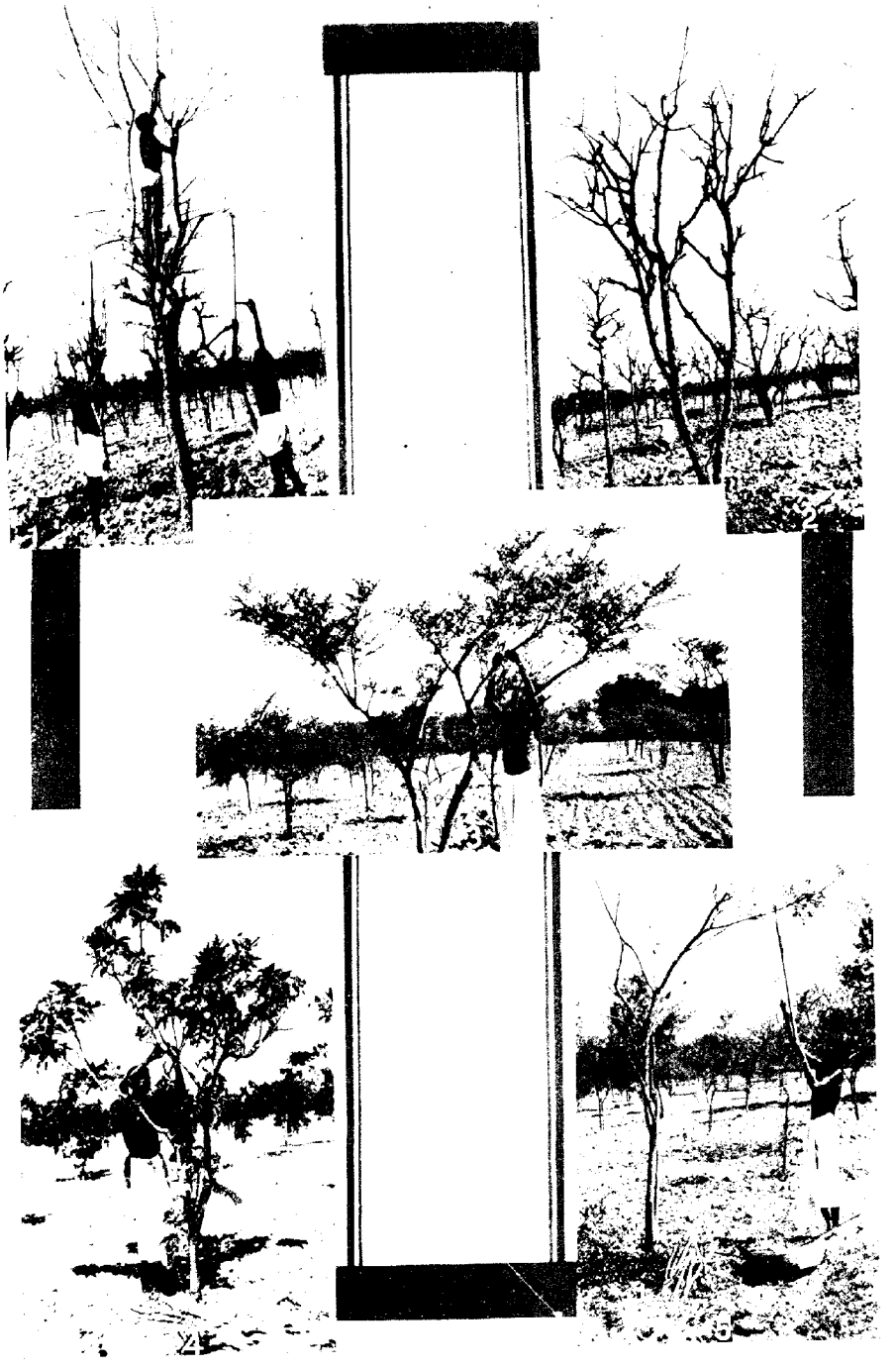


PLATE II.

Lac cultivation, pruning, infection reaping.

1. Pruning *Acacia Catechu* (Khair). Experimental Plantation, Namkum.
2. *Acacia Catechu* pruned prior to lac infection. Experimental Plantation, Namkum.
3. Infecting *Zizyphus Jujuba* (Ber). Experimental Plantation, Namkum.
4. Infecting *Schleichera trijuga* (Kusum). Experimental Plantation, Namkum.
5. Reaping Lac from *Zizyphus Jujuba*. Experimental Plantation, Namkum.

sixteenth is developing successfully. The asexually produced females are in no way harmed, the lac produced, their fertility, and the sex ratio of their progeny compares favourably with that of normally sexually produced females. This form of asexual reproduction in which, unfertilised females give rise to a progeny of both males and females is termed Deuterotoky.

In practice this means that male intervention is unnecessary and that elimination of the males, therefore, would be of value to the cultivator, thus allowing the whole of the available space to be utilised by females. The factors controlling the percentage of males in the crop are under investigation at the Institute but no method of eliminating males from the progeny of the lac females has yet been discovered. The phenomenon of parthenogenesis is of importance in nature in that it means that adverse climate factors, such as heavy rain at male emergence which may easily occur in the Katki crop, killing the males and wholly or partly preventing fertilisation can operate without harming the yield of lac or the production of young.

Female Insect.

The female larva having once settled down never moves again. Inside her cell she undergoes three ecdyses or moults, losing eyes and legs and having only rudimentary antennæ. The female continues however to secrete lac and the female cells increase in size, and the originally thin encrustation of lac becomes a thick coating partly or completely surrounding the twigs of the host tree. It is thus the female which is responsible for the production of the lac encrustation, the empty male cells become occluded by them. If the encrustation is dissolved in a solvent as for example alcohol, empty male cells can be discovered. This coating or encrustation together with the cast skins (exuviæ) of the insects is the lac of commerce.

Honey Dew.

Through the anal tubercular pores of the lac cells a sweet sticky substance, known as 'honey dew' is also secreted, and forms a sticky covering on the twigs and upper surfaces of the leaves of lac bearing trees. It forms a nutrient material for a black fungoid growth, species of *Capnodium* and *Fumago,* which overspreads the twigs and upper surfaces of the leaves of lac infected trees, giving them a characteristic black sooty appearance. The same sooty black coating is often found on the ground beneath lac infected trees or on any vegetation growing beneath them. The fungus appears to be a harmless saprophyte. The honey dew also is attractive to ants who frequently visit lac infected trees to obtain it.

Fungus.

Egg laying and emergence of larvæ.

The eggs during this time are developing in the paired ovaries in the bodies of the females and finally mature, and are oviposited into a space formed inside the lac cell, by contraction of the body of the female, which is known as the incubating chamber. Here they hatch into larvæ which finally emerge from the cell *via* the anal tubercular opening. This emergence has already been referred to and is known as swarming. It continues for about 3 weeks. The period of growth from the egg to the mature female giving rise to eggs again is known as a life cycle or generation and corresponds to a lac crop.

Life Cycle. The life cycle can occur twice in a period of 12 months, actually however there are four life cycles and hence four crops per annum because the lac insect behaves in two ways according to whether it is grown on *Schleichera trijuga* (Kusum) or on hosts other than Kusum using brood other than Kusum.

Trivoltine lac insect. Two life cycles per annum applies in practically every district in which lac is grown, there is in Mysore however a trivoltine strain of lac insect grown on *Shorea talura,* which passes through three life cycles in thirteen months. The actual periods of the life cycles quoted below apply with only slight modification in all the major areas of lac cultivation, but do not apply in Burma and Assam. The periods of these cycles depends at least to a large extent on climatic conditions, an example of this is the fact that when a consignment of the Mysore trivoltine insect was brought to Namkum and grown on *Shorea talura,* it did not pass through three cycles in the year but only two.

Lac Crops. The four lac crops are named after the Hindi months in which they are cut from the tree, but it must be made clear that lac is not always left on the tree until it matures fully; particularly in the case of the Baisakhi crop most of the lac is cut immature leaving a certain proportion on the tree to act as brood for the next crop. This premature cutting does not entail any appreciable loss in resin, in the Baisakhi crop. (This is fully explained in Chapter XII and XXII). In the other crops also, lac not required for brood purposes is frequently cut before the female insects are fully mature.

Katki. When the lac larvæ are inoculated on host trees in June—July the male insects emerge in August—September, and the females are ready to give out a swarm in October—November. This is called the Katki (or Rangeen) cycle or crop. The Katki crop is generally cut in the month Katik, October—November, when of course it is mature.

Baisakhi. The larvæ from the brood lac produced by the Katki crop, settle down in October—November, on the new host trees, the male insects emerge in February—March, and the females are ready to give out a swarm in June—July. This is called the Baisakhi (Hari, in the Punjab) crop. Brood lac from this crop is used to infect the trees for the Katki crop, and so on. The Baisakhi crop is usually cut in part in the month Baisak, April—May while still immature, a certain amount being left on the trees to mature in June—July for use as brood. (This is fully explained in Chapters XII and XIII).

In the major lac growing districts the Baisakhi crop is the commercial crop, the Katki is the brood crop for the Baisakhi although it is also a commercial crop to a lesser extent.

Aghani. When lac is grown on *Schleichera trijuga* (Kusum) or if brood lac from Kusum is used to inoculate other host trees, a rather different life cycle occurs. When larvæ are inoculated on Kusum or larvæ from Kusum brood are inoculated on any host tree in July, the males emerge in September, but the females are not ready to produce a swarm until January—February. This is called the Aghani (Kusmi or Nagoli) crop. Although the Aghani crop

does not mature till January—February, cutting of it for sale purposes begins in the month Aghan November—December. This premature cutting is wasteful as secretionary activity in the Aghani crop continues up to the time of swarming. and by premature cutting, resin that would have been secreted in the remaining period is lost.

Jethwi.

The larvæ from the Aghani crop are inoculated on Kusum or other hosts in January—February, the males emerge in March—April and the females are ready to produce larvæ in June—July. This is called the Jethwi crop, the larvæ from it, infected on Kusum or other hosts in July will give rise to an Aghani crop again. The Jethwi crop is largely used as a brood crop for the Aghani which is the commercial crop, and is usually not cut till mature.

It will be seen, therefore, that lac which has not been grown on Kusum, will retain the Katki and Baisakhi seasons for its life cycles. Lac grown on Kusum, and lac which has been grown on Kusum and is then grown on other hosts retains the Aghani and Jethwi seasons for its life cycles.

Rangeeni and Kusmi lacs.

In this book where a lac is referred to as *Rangeen* it means that it has *not* been grown on Kusum and that it takes the Katki and Baisakhi cycles. Where it is referred to as *Kusmi*, it means that it is either grown on Kusum, or is the result of Kusum brood, and that it takes the Aghani and Jethwi cycles.

Table I, summarises the information as regards the four lac crops and it is essential that the cultivator should be fully conversant with the data there summarised. It will be seen that there are four lac crops, Katki, Baisakhi, Aghani and Jethwi ; that there are three seasons at which infection of lac hosts may be carried out, June-July, October-November and January-February, and that there are four seasons at which crops can be reaped, June-July, October-November, January-February, and April-May.

TABLE I

Infection with swarming larvæ.	*Emergence of male insects.*	*Crop Reaped.*	*Female insects mature and give rise to swarming larvæ.*
Rangeen or non-Kusum crops (major crops in most Districts).			
Katki Crop. June-July ...	August-September	October-November	October-November
Baisakhi Crop. October-November ...	February-March	April-May, leaving a certain amount of lac on the trees to mature and act as brood in July.	June-July.
Kusmi crops. (minor in most Districts).			
Aghani (Kusmi) Crop. June-July ...	September ...	December-January, lac not required as brood.	January-February
Jethwi Crop. January-February ...	March-April ...	June-July	June-July

The males of the Katki and Aghani crops are mainly apterous (wingless), those of the Jethwi and Baisakhi crops are mixed, some winged, some apterous. Kusum lac is more valuable than non-Kusum lac, Baisakhi lac fetches a better price than Katki lac.

When lac is cut from the tree mature a part is generally set aside for use as brood and the remainder is sold for manufacture into shellac. Immature, lac being of course of no use as brood lac, is all sold for manufacture.

Scraping lac. Prior to sale the lac encrustation is scraped from the twigs by means of knives or is broken off with the fingers. In the case of Kusum lac the encrustation is less easy to separate from the stick as it often surrounds the twigs, it frequently reaches the market cut into short pieces of one to three inches in length still on the stick. In the condition scraped from the stick, it is known to the trade as stick lac. After scraping, the sticks usually contain a small amount of resin and make good firewood.

Ari and Phunki lac. Lac may be sold for manufacture in two conditions. If it is immature or has been cut some time before swarming and contains the living insects it is known as "ari". If it has been cut after swarming or been cut and allowed to swarm before sale and contains only the dead bodies of the insects it is known as "phunki". Brood lac after use may be scraped also and the scraped lac sold for manufacture, it being then of course phunki.

Lac dye. It is the colouring matter of the insect bodies dead or alive which forms the crimson lac dye when lac is washed. It was for this colouring matter or lac dye, that lac was originally cultivated. Lac dye though in many ways inferior to Cochineal (which is also a natural product being made from an insect related to the lac insect *Dactylopius coccus* (*Coccus cacti*) a native of Mexico feeding on certain species of Cactus) was found to be cheaper and to serve the same purpose, and a large trade in this product sprang up. The discovery of aniline dyes by Sir W. H. Perkin and others however, and the perfection of chemical dyes in general put an end to the cochineal and Indian lac dye trades, and lac dye has now only a very limited market.

Blocking. When lac is cut from the tree ari it is necessary to take certain precautions to prevent it "blocking". This condition is the result of warmth and pressure on the fresh lac containing as it does the bodies of the female insects, causing it to stick together into a hard almost unbreakable mass. These precautions are explained in Chapter VIII.

Successful Cultivation of Lac. It will be seen, that the successful cultivation of lac depends primarily on making the optimum use of the life cycle of the lac insect. The insect is however closely related to the tree on which it is living and feeding, successful cultivation must, therefore, depend secondarily on the correct use and treatment of the host tree.

CHAPTER II.

THE PRODUCTION OF STICKLAC IN INDIA AND ELSEWHERE.

It has been stated in the previous chapter that the production of lac is virtually a monopoly in the hands of India.

Areas where lac is grown.

Lac is cultivated in India to a greater or less extent in Bihar, Orissa, Bengal, Burma including the Federated Shan States, Assam, Bhutan, Thibet, Nepal, the United Provinces, the Punjab, Bombay, Sind, Central India, Central Provinces, Berar, Hyderabad (Deccan), Rajputana, Madras, Mysore, Kashmir and Travancore. The area of major importance however comprises, Chota Nagpur, the Feudatory States of Orissa, Central Provinces and a few adjacent areas in Bengal and the United Provinces.

Major areas of cultivation.

This area may be said to produce something like 90% of the lac of commerce, and in it, Chota Nagpur is the tract of greatest production and can claim over 50% of the out turn of this country.

Among the important lac growing Districts in Bihar are Ranchi, Palamau, Manbhum, (Balarampur and Jhalda), and Singhbhum, all of which are in Chota Nagpur ; Pakaur in the Sonthal Parganas produces only small amount of lac. Important areas or markets elsewhere include Kota-Pendra, Rajim-Dhamtari, Gondia and Katni-Damoh in Central Provinces, Umaria in Rewa State, Central India ; and Dhulian, Nimtita and Malda in Bengal.

Areas of manufacture.

The principal centres of manufacture are Mirzapur, Balarampur and Jhalda in Manbhum, and Calcutta ; other important centres are Ranchi, Bundu and Murhu in the Ranchi District, Pakaur in the Sonthal Parganas, Imamganj —Raniganj in the Gaya District, Gondia in Central Provinces and Umaria in Rewa State.

Production of lac in India.

Figures for the production of stick lac in India prior to 1928 are only available for certain years. The estimated production for the years 1918-1921 is given in Table II.

TABLE II

Production of stick lac in India in Maunds.

Crop.	1918	1919	1920	1921
Baisakhi ...	4,75,000	5,26,700	6,40,000	7,11,200
Jethwi ...	not available	65,900	61,700	55,500
Katki ...	1,91,000	2,59,100	3,96,600	2,73,800
Aghani ...	1,16,000	64,500	1,26,200	1,16,900
	7,82,000	9,16,200	12,24,500	11,57,400
	(Jethwi not included figures not available).			

Table III gives the estimated production in maunds of the four lac crops from 1928 to the present time, in the twelve reporting areas, which include practically the whole of India, but do not include Assam or Burma.

TABLE III

Production of lac in maunds in the reporting areas (cf. page 13) not including Assam and Burma.

YEAR.	1928	1929	1930	1931	1932	1933	1934	1935	1936
Baisakhi	7,81,826	5,72,500	7,94,500	5,93,000	5,51,500	4,91,000	6,37,000	6,33,000	7,53,000
Jethwi	1,17,250	42,250	46,000	30,500	37,000	45,000	23,000	30,000	1,00,000
Katki	2,52,500	2,40,000	2,72,500	1,28,250	1,14,000	3,18,250	2,13,750	1,90,500	3,46,250
Aghani	3,05,000	1,57,750	1,56,000	92,500	1,53,600	1,21,250	1,03,550	2,03,000	3,80,750
Total	14,56,576	10,12,500	12,69,000	8,44,250	8,56,000	9,75,500	9,76,800	10,57,500	15,80,000

To these figures must be added the following figures which are the approximate estimated normal annual production of the non-reporting areas, the actual production at the present may be taken to amount to very approximately 75% of these figures.

Baisakhi	9,000 maunds.
Jethwi	1,500 ,,
Katki	5,500 ,,
Aghani	1,500 ,,
Total:	17,500 maunds.

The production of stick lac in India including Assam but not including Burma therefore falls between the maximum and minimum of 9 and 16·5 lakhs of maunds. The average production is roughly 10·5 lakhs of maunds per annum.

The important lac growing area extending over Bihar, Bengal, Central Provinces, Punjab, United Provinces, Orissa, Bombay and a score of Indian States has for purposes of crop reporting been divided into 12 divisions. In many cases one division covers more than one Province, it may also include one or more States. The divisions are named after the principal lac market or markets. They are listed below.

The reporting areas are the following:—

Jhalda. In the Manbhum District, host trees mainly Ber, Palas and Kusum.

Balarampur. Also in Manbhum, host trees mainly Ber.

Ranchi. The plateau is about 2,100 ft. Host trees Kusum Ber and Palas. **Bihar.**

Singhbhum. This division includes Mayurbhanj and Keonjhore and certain other Indian States of the Eastern Agency. Host trees are Kusum and Ber mainly.

Daltonganj. Includes Sirguja State and lac from the Dudhi area of the Mirzapur district. Host trees mainly Palas.

The production of Mayurbhanj State is very approximately 11,000 to 21,000 maunds annually, the greater part of which is Kusmi. The annual production of Sirguja State is between 30,000 and 60,000 maunds, which is almost entirely Rangeeni.

Pakaur. Sonthal Parganas District, includes the production of Malda and Murshidabad District in Bengal which approximates to 80,000 maunds per year, and also the production of Nepal which does not exceed 2,000 maunds per annum. Ber is almost the only host tree.

Kota-pendra. Some of the production of this centre is from the Sirguja State. Principal host tree Palas.

Rajim-Dhamtari. Includes the Raipur District. Host trees Kusum and Palas, includes lac from adjoining States. **Central Provinces.**

Gondia. Mainly Palas lac.

Katni-Domoh. Important hosts are Palas and Ghont.

The above four divisions are in Central Provinces.

Umaria. Umaria is in Rewa State, Central India, the main host trees are Palas and Kusum.

Other minor Divisions include, *Imamgunj—Ranigunj;* and *Chatra—Sherghati* in Bihar; *Raigarh—Champa, Naila—Rajnadgaon, Saugar—Harpalpur,* and *Itarsi—Bankheri* in Central Provinces; *Hosiarpur*—Punjab, *Mirzapur—Lucknow* in United Provinces; *Satna—Maihar* in Central India; *Bombay—Baroda, Chotaudaipur* Bombay; *Bhopal—Betul, Gangpur—Sambalpur* the latter in Orissa, and *Hyderabad—Sindh.*

In order to show the relative importance of these twelve divisions Table IV has been drawn up. The productions are worked out on a seven year average over the years 1930-31, 1931-32, 1932-33, 1933-34, 1934-35, 1935-36, 1936-37.

Relative importance of the crops.

It will be seen from Tables III and IV that the Baisakhi is the major crop, that the Katki and Aghani are the next in importance and that the Jethwi is the minor crop. The Baisakhi is the major commercial crop, and the Katki is the brood crop for the Baisakhi but is a commercial crop also. The Aghani is a commercial crop and the Jethwi is largely a brood crop for the Aghani.

The Baisakhi crop fluctuates between 4·5 and 7·5 lakhs of maunds and the Katki and Aghani between 1·5 and 3·5 lakhs, except in 1931 when the Aghani crop was abnormally small; the Jethwi crop fluctuates from just less than 0·5 lakhs to just over a lakh of maunds. The total crop yields vary from 8·5 to 15·5 lakhs. It will be seen that in spite of low prices prevailing all crop yields for 1936 are high.

TABLE IV

Average production of lac in the four crops in the twelve reporting divisions, (based on a seven year average), in maunds.

Division.	*Baisakhi.*	*Jethwi.*	*Katki.*	*Aghani.*	*Total.*
1. Ranchi (Bihar) ...	85,000	9,400	22,400	47,300	1,63,100
2. Jhalda (Bihar) ...	91,400	7,300	24,700	30,200	1,53,600
3. Balarampur (Bihar)	91,000	6,300	16,900	34,900	1,49,100
4. Daltonganj (Bihar) including Sirguja State	93,700	460	26,900	2,600	1,23,660
5. Other Minor Divisions	71,900	4,600	31,800	9,900	1,18,200
6. Singhbhum (Bihar) ...	41,900	9,100	10,600	29,500	91,100
7. Pakaur (Bihar, Bengal, Nepal)	62,400	*nil*	23,800	*nil*	86,200
8. Gondia (C. P.) ...	27,000	*nil*	27,700	140	54,840
9. Kota-pendra (C.P.) ...	28,400	140	17,400	1,400	47,340
10. Rajim Dhamtara (C.P.)	6,600	6,700	6,600	16,600	36,500
11. Umaria (Rewa State, Central India) ...	27,000	40	8,400	530	35,970
12. Katni-Damoh (C.P.) ...	9,900	*nil*	10,300	*nil*	20,200
Total ...	6,36,200	44,040	2,27,500	1,73,070	10,80,810

The annual production of stick lac in Assam is recorded in Table V.

TABLE V

Estimated stick lac production in Assam in maunds.

Production of lac in Assam.

Year.	*Stick lac production.*	*Year.*	*Stick lac production.*
1928 ...	... 43,000	1933 ...	... 22,000
1929 ...	... 44,250	1934 ...	... 45,000
1930 ...	... 55,000	1935 ...	... 36,000
1931 ...	... 45,000	1936 ...	... 31,000
1932 ...	... 28,500		

The estimated normal production of Assam is 47,000 maunds. It will be seen that the Assam production has remained fairly constantly between roughly 30 and 45 thousand maunds during the last 8 years. The whole of the production of Assam finds its way into Calcutta for manufacture and export.

The annual production of stick lac in Burma is recorded in Table VI.

TABLE VI

Stick lac production in Burma in maunds.

Production of lac in Burma.

Year.	*Stick lac production.*	*Year.*	*Stick lac production.*
1927 ...	... 90,710	1932 ...	... 37,500
1928 ...	... 1,62,180	1933 ...	... 26,000
1929 ...	... 1,63,000	1934 ...	... 50,500
1930 ...	... 92,000	1935 ...	... 55,000
1931 ...	... 63,250	1936 ...	(figures not available).

The greater part of the stick lac production of Burma is shipped from Rangoon to Calcutta, figures for recent years are given in Table VII.

TABLE VII

Imports of stick lac into Calcutta from Rangoon in maunds.

Year.	*Import in maunds.*	*Year.*	*Import in maunds.*
1931 ...	... 26,300	1934 ...	... 1,17,200
1932 ...	... 36,150	1935 ...	... 31,000
1933 ...	... 36,500	1936 ...	... 20,650

It will be seen that the imports from Rangoon have remained fairly stationary during the last six years at between 20—35 thousand maunds, the year 1934 being exceptional, the large import being due to the operations of the shellac pool on the London market and the consequent heavy demand for shellac.

The normal influx of stick lac into India from Burma and Assam is between 50—80 thousand maunds.

Share of the Provinces in production.

In Table VIII an approximate account has been given of the production of lac in India Province by Province including Assam and Burma, based on an average of seven years, this table must not be considered to be an accurate average as approximations and in several cases estimates have had to be made from very scanty data.

It will be seen that Bihar, after the substraction of the production of Bengal and Nepal, and the addition of that of Imamganj—Raniganj 18,000 and Chatra—Sherghati 12,000 maunds, produces roughly 7 lakhs of maunds, while India as a whole produces about 11 lakhs. In fact $\frac{2}{3}$rds of the lac produced in India comes from Bihar. All the areas of production in Bihar except the Dumka District in the Pakaur Division, Sonthal Parganas are in Chota Nagpur which may be said therefore to produce well over 50% of the lac outturn of India.

TABLE VIII

Approximate estimate of the average annual production of stick lac of the various provinces in maunds.

	Maunds.
Bihar including Mayurbhanj and Sirguja State ...	7,16,000
Central Provinces	1,60,000
Bengal	80,000
Burma	52,000
Assam	37,000
Central India	36,000
Punjab	10,000
Bombay-Baroda	9,000
United Provinces	5,500
Orissa (including Gangpur State)	4,500
Hyderabad Sindh	4,000
Nepal	2,000
Hyderabad Deccan	500
Bhopal	200
Rajputana, Madras, Bhutan, Thibet, Berar, Kashmir, Mysore, Travancore	Small or very small quantities.
Total	... 11,16,700

The influx of lac from countries outside India and Burma is examined in the following paragraphs. The exports of stick lac from Bangkok are given in Table IX.

TABLE IX

Exports of stick lac in maunds from Bangkok.

Year.	*World Ports including Calcutta.*	*Calcutta.*	*Singapore.*	Exports from Bangkok.
1926 ...	... 52,000	*nil.*	25,500	
1927 ...	... 58,800	„	42,000	
1928 ...	... 57,500	„	33,000	
1929 ...	... 1,57,200	„	1,31,500	
1930 ...	... 55,800	„	42,400	
1931-32	... 15,128	„	figures not available.	
1932-33	... 8,835	„	„	
1933-34	... 1,11,764	„	„	
1934 ...	figures not available.	10,340	„	
1935 ...	„	17,900	„	
1936 ...	„	28,700	„	

It will be seen that the greater portion of the export of Bangkok has in the past found its way to Singapore from whence reference to Table X will show that the majority of it reaches Calcutta. In recent years some stick lac has been imported into India direct from Bangkok.

Table X summarises the exports of stick lac in maunds from Singapore.

TABLE X

Export of stick lac in maunds from Singapore.

Year.	*World Ports including Calcutta.*	*Calcutta.*	Exports from Singapore.
1922	... figures not available.	25,400	
1923	... „	12,200	
1924	... „	10,300	
1925	... „	300	
1926	... 21,600	10,200	
1927	... 49,900	33,000	
1928	... 32,200	15,300	
1929	... 1,15,800	1,01,500	
1930	... 53,500	47,800	
1931	... figures not available.	13,400	
1932	... „	3,450	
1933	... „	14,200	
1934	... „	1,79,300	
1935	... „	67,100	
1936	... „	1,17,400	

Note on imports of lac into India.

It will be seen that the greater part of the stick lac export from other countries is to Calcutta, of the total export only approximately 10,000 maunds annually reaches the world without passing though the hands of the Indian manufacturer and shipper.

During the year 1934, imports of stick lac into India reached their maximum, and in addition to the imports recorded in the tables, 139 maunds were imported from Hongkong and 238 maunds from Canton.

The year 1934 must be regarded as a special case as it was at this time the operations of the shellac syndicate in London made themselves felt. During the year 1936 crops in India were large and imports also were considerable in spite of low prices. This is due in part, at least, to an increase in the exports of manufactured lac, which may be accounted for to some extent as the result of a slow world trade recovery which it is hoped will be maintained. It should be pointed out however that the imports of stick lac into India from other countries are on the increase. The 1936 figure being approximately 1·5 lakhs.

Comparison of these figures with the export figures of manufactured lac given in 'Lac and the Indian Lac Research Institute*, show that when exports from India are high imports from Bangkok and Singapore have been high and *vice versa*. It is pointed out in Chapter IX that Baisakhi type lac cannot be economically washed to give a "Seedlac" for export with low insolubles, that this seedlac is always blended with a proportion of Kusum type seed lac, and that lac from Burma and Siam is convenient and cheap for this purpose. Thus in a year when exports of seed lac are high imports of Burma and Siam lac are likely also to be high. Reference to the data given in "Lac and the Indian Lac Research Institute"* by Norris, Glover and Aldis clearly shows that the export of seedlac is on the increase. This means that such imports are not actually entering into competition with Indian stick lac, but are governed by European demand, and price, factors.

* Obtainable from the Director, Indian Lac Research Institute.

CHAPTER III

PRICES OF UNMANUFACTURED LAC 1929—1937.

In order to give some idea of the prices realised by the sale of brood and sticklac a summary has been drawn up (Table XI) in which the data available at the Indian Lac Research Institute of the prices of Kusum, Palas and Ber brood, and scraped, lacs during the period 1929 to 1937 are recorded. The prices are those paid or received by the Institute for the various types of lac but represent fairly closely the general market prices prevailing in the Ranchi District, and may be taken as being indicative of prices as a whole.

Market Trends.

The figures show two quite definite market trends. Firstly a gradual drop in prices for all types of lac from 1929 to 1931. If figures were available for a few years earlier than 1929, they would show a drop from an even higher price. Prices from 1931 to 1933 remained fairly steady at this low level.

Effect of World Depression.

This fall in price was largely due to general world depression and more particularly due to the economic depression in America which led to the decline of the gramophone industry which was further depressed by the development of the radio trade. Competition from synthetic products may be also held responsible to some extent for the decline in price.

Operation of the Shellac Syndicate.

During early 1934 prices showed a very considerable increase. This was due to the operations of the Shellac Syndicate, a body of speculators who attempted to make a corner in shellac. Towards the end of 1934 and in 1935 prices declined; this decline was due to the failure of the shellac pool.

Present prices of sticklac have now returned to approximately those prevailing before the shellac pool began its operations.

Present position and future of the Industry.

There seems little likelihood that the high prices for lac and shellac obtained during the year 1929 and those immediately preceding it will ever occur again. Shellac is competing with synthetics on the world's markets largely on a price basis, should the price of shellac increase considerably it would no longer compete successfully with synthetic products.

Shellac is however at present competing successfully in the world's markets, and in spite of world depression in the past years, the exports of shellac from India have returned to rather more than the 1925 level. Should the American demand increase there is a prospect of greater exports and possibly a corresponding rise in price.

TABLE XI

Prices of unmanufactured lac 1929—1937 in rupees per maund of stick or brood lac.

	Rs.	A.	P.	
July 1929.				
Palas ari	44	0	0	(Scarce)
Palas brood ...	67	0	0	
Ber brood ...	22	0	0	
Kusum brood ...	78	0	0	
September 1929.				
Palas phunki ...	41	0	0	
	to			
	49	0	0	
Ber	49	0	0	
October-November 1929.				
Palas brood ...	20	0	0	
Ber brood ...	37	0	0	
December-January 1929-30.				
Palas phunki ...	22	0	0	
	to			
	28	0	0	
January-February 1930.				
Kusum brood ...	61	0	0	
Kusum × Khair brood	61	0	0	
Palas phunki and ari	43	0	0	
April 1930.				
Kusum	45	0	0	
Kusum × Khair ...	45	0	0	
Katki (mixed) ...	24	0	0	
Ber	27	0	0	
June-July 1930.				
Kusum brood ...	28	0	0	
	to			
	36	0	0	
Palas brood ...	20	0	0	
	to			
	22	0	0	
Ber brood ...	20	0	0	
September 1930.				
Palas	28	0	0	
Ber	27	0	0	

	Rs.	A.	P.
October-November 1930.			
Palas brood ...	26	0	0
Ber brood ...	26	0	0
Palas	12	8	0
Ber	12	8	0
January-February 1931.			
Kusum brood ...	20	0	0
	to		
	23	0	0
Kusum × Khair brood	20	0	0
	to		
	25	0	0
July 1931.			
Ber brood ...	13	0	0
Palas brood ...	12	0	0
Kusum brood ...	15	0	0
Kusum × Khair ...	17	0	0
August 1931.			
Palas ari lac ...	12	0	0
Kh. prog. K × K ...	17	0	0
Pure Kusum ...	17	0	0
Palas × Ber ...	17	0	0
October 1931.			
Ari Palas	13	0	0
Ari Ber	13	0	0
Ber brood ...	8	0	0
Palas brood ...	8	0	0
November 1931.			
Palas brood ...	9	8	0
January 1932.			
Kusum lac ...	16	0	0
Palas phunki lac ...	14	0	0
Ari Kusum lac ...	15	0	0
February 1932.			
Kusum brood ...	16	0	0

Prices of unmanufactured lac 1929—1937 in rupees per maund of stick or brood lac.—Continued.

	Rs.	A.	P.
April 1932.			
Ari Palas lac ...	7	0	0
Palas lac	7	8	0
June 1932.			
Palas lac	6	8	0
Ber lac	6	8	0
July 1932.			
Kusum brood ...	13	0	0
Palas brood ...	11	0	0
Ber brood ...	11	0	0
September 1932.			
Palas phunki ...	6	4	0
Palas ari	5	0	0
Ber ari	5	0	0
Kusum ari ...	13	0	0
November 1932.			
Kusum lac ...	13	0	0
Ber lac	11	0	0
Ari Kusum ...	11	0	0
Phunki Ber ...	12	0	0
Ber brood ...	20	0	0
December 1932.			
Phunki Palas ...	8	0	0
January 1933.			
Scraped Kusum ...	11	0	0
Kusum ari ...	13	0	0
February 1933.			
Kusum brood ...	14	0	0
Kusum ari ...	14	0	0
June 1933.			
Ber brood ...	9	0	0
July 1933.			
Kusum brood ...	12	0	0
Phunki Kusum ...	12	8	0
Ber brood ...	10	0	0
Palas brood ...	11	0	0
August 1933.			
Kusum phunki ...	12	8	0
October 1933.			
Ber brood ...	8	0	0
Palas brood ...	8	0	0
Ber scraped ...	8	8	0
November 1933.			
Scraped Ber ...	10	0	0
Phunki Palas ...	9	12	0
Ari Kusum ...	12	4	0
January-February 1934.			
Kusum brood ...	30	0	0
	to		
	37	8	0
	to		
	45	0	0
May 1934.			
Sraped ari Ber ...	30	0	0
Scraped ari Palas ...	29	8	0
July 1934.			
Palas stick lac ...	27	0	0
Scraped ari Kusum	40	0	0
August 1934.			
Ber brood ...	30	0	0
Kusum brood ...	35	0	0
Ber scraped ...	23	0	0
October 1934.			
Ber brood ...	23	0	0
Palas brood ...	24	0	0

Prices of unmanufactured lac 1929—1937 in rupees per maund of stick or brood lac.—Continued.

	Rs.	A.	P.
November 1934.			
Scraped ari Palas ...	25	0	0
Scraped ari Ber ...	25	0	0
Ber Phunki lac ...	25	0	0
December 1934.			
Palas phunki lac ...	16	0	0
January 1935.			
Ari Kusum lac ...	29	0	0
February 1935.			
Kusum brood ...	39	0	0
March 1935.			
Kusum lac ...	22	8	0
July 1935.			
Kusum lac ...	26	0	0
Ber lac ...	22	8	0
Palas brood ...	22	0	0
Ber brood ...	22	0	0
Kusum brood ...	24	0	0
August 1935.			
Palas brood ...	23	0	0
Ber brood ...	23	0	0
November 1935.			
Palas brood ...	21	0	0
Ber brood ...	21	0	0
February 1936.			
Kusum brood ...	19	0	0

	Rs.	A.	P.
March 1936.			
Kusum lac ...	12	0	0
June-July 1936.			
Kusum brood ...	14	0	0
to	15	0	0
Palas brood ...	13	8	0
to	14	0	0
Ber brood ...	11	0	0
Kusum lac ...	12	0	0
to	12	8	0
Palas ari ...	8	0	0
September-October 1936.			
Ber brood lac ...	5	0	0
Palas brood ...	7	0	0
November-December 1936.			
Palas phunki ...	8	0	0
to	11	0	0
January-February 1937.			
Kusum brood ...	15	0	0
Kusum phunki ...	12	0	0
June-July 1937.			
Palas brood ...	12	0	0
Ber brood ...	8	0	0
Kusum brood ...	18	0	0
to	25	0	0

Very scarce.

Stick lac prices depend upon the price of shellac; as a very rough guide, Rangeeni stick lac will fetch $\frac{1}{3}$rd the current price of T. N. Shellac and Kusmi stick lac $\frac{1}{3}$rd the price of Superfine shellac.

CHAPTER IV.

GENERAL NOTES ON THE METHODS AND PRACTICE OF LAC CULTIVATION.

Cultivation of Lac by Raiyats.

Lac can be grown by two classes of producer. First, the more wealthy cultivator, who either owns or rents the lac hosts and hires the necessary labour to carry out the operations of cultivation. Whether he works on a plantation scale or cultivates on trees on waste land, the actual number of trees under his control is likely to be large. Secondly the raiyat, cultivating lac on his own or rented trees and utilising family labour. The number of trees cultivated by any individual raiyat is likely to be small. By far the greater amount of lac grown in India is cultivated by raiyats.

In raiyat cultivation a portion of each crop produced is retained for use as brood for the next crop, and the remainder is sold for manufacture. The raiyat in the general way is provident and takes care that he does not have to purchase brood lac, although there is a tendency to sell when prices are high without retaining sufficient lac for use as brood and to neglect crops when prices are low. He also tends in times of poverty to sell his lac for what he can get for it, regardless of the future.

Costs of Raiyat Cultivation.

The important point as regards raiyat cultivation is that it is a cottage industry, and that his labour is his own, or his family's, *and costs him nothing*: Although its actual value if it were to be paid for in cash would be in the neighbourhood of Rs. 6/- per maund scraped lac produced. The result of this is that the raiyat can, and in many districts, actually will, grow lac at a very low price indeed, provided he gets *some* return, as it represents only a subsidiary crop to his food crop which is mainly rice; his revenue from lac he relies upon to a large extent for the amenities of life. The cultivation of lac also does not entail a great deal of labour; work is seasonal being limited to the pruning, infection and cropping seasons and then lasting only for a few days. In addition the raiyat does not have to meet Chowkidari charges to guard against theft, as would a private individual.

Thus even were the price of lac to fall to a few rupees per maund, it would still be cultivated in a good many districts. Cultivation would, however, tend to be neglected in those districts where the raiyat could turn his hand to other crops, and in some districts he might consider the labour involved in cultivation was not justified by the return.

Rent paid by Raiyats.

There are two main types of raiyat cultivation, according to whether the raiyat owns the trees or not. Where he owns his own trees, his outgoings are nil as his labour is his own. Where the trees are not his own he has to pay rent in some form or another. Where rent is charged, the outgoings are of course the rent paid for the trees. Where the landlord loans his trees

to the villagers and takes in return one-half of the crop, the outgoings may be assessed as half the prevailing price of stick lac.

Ownership of Lac Hosts.

The invariable custom appears to be that all lac bearing trees in the jungles belong to the landlord whether proprietor or tenure holder, and cannot be cut by the tenants under any circumstances. In actual practice however lac is rarely set on trees in the jungle.

Lac bearing trees in waste land also generally belong to the landlord unless, planted or reared by the tenant. The tenant is supposed to take permission to plant trees on waste land. In the Chota Nagpur settlement the absence of any objection by the landlord was regarded as tacit permission. The Landlord however has a right to object and if he does the tree will not belong to the planter.

On old holdings the trees normally belong to the landlord unless the tenant has planted or reared them. The tenant however normally has the right to set lac on all trees in his holding, sometimes on payment of half produce, sometimes a cash rent is paid, and sometimes no rent at all is charged.

There appears to be no hard and fast rule on this point, but the general principle underlying is that trees planted or reared by a tenant belong to him, and all others to the landlord. This varies in inverse ratio to the degree of cupidity of which the landlord is capable, and the amount of opposition that the tenants can put up.

Landlords generally lease Kusum trees on the half produce system. Instances are found however where cash rent for the trees is realised. The rent charged varies over a very wide figure from district to district and for various kinds of trees. Rent charged for Kusum trees in Government Khasmahal varies from 1 anna to 9 as. or even more and averages about 4-6 as. per tree in Chota Nagpur. Rent charaged for Ber trees averages about 2-4 as. and Palas about 1-2 as. However no definite figures can be given.

Acknowledgments are due to the Chota Nagpur Settlement Department for much of this information.

Cultivation by Private Individuals.

The argument here is that the raiyat can and will cultivate lac, even at a very low price indeed; the private individual on the other hand cannot. He can of course lease his trees out to the raiyats in either of the ways mentioned above, taking a fixed rent per tree or taking half the crop. Private individuals who wish to interest themselves in lac cultivation are advised to do so in this way. In either case, he should for the sake of his trees, and in the second for the sake also of the share of the yield he will obtain, educate his tenants to grow lac according to the methods here explained.

He may in addition attempt to grow lac under plantation conditions, or he may cultivate his own trees, or rented trees, paying for labour. The private individual is not advised to do this unless he can keep overhead costs at a

very low figure, and is prepared to accept an extremely small return for his trouble.

A comparison of the lac prices quoted in Table XI, and the cost of production of a maund of scraped lac, will make this clear.

Cultivation under Plantation conditions.

At the present prices prevailing in the lac industry (see Chapter III) growth of lac in plantations is almost certain to be an economic failure, and may be said to be certain to be a failure if the cultivator has to purchase brood lac. The actual labour charges necessary to produce 1 maund of cleaned scraped Palas stick lac, are in the region of Rs. 6/- per maund, the selling price of 1 maund of Palas clean lac during 1936 averaged about Rs. 8/- per maund. This leaves Rs. 2/- per maund produced, for overhead charges, plantation maintenance, management charges and for guarding the lac against theft.

Cost of production.

It will be seen, however, that provided the production of lac is large and maintenance, overseeing, and overhead charges are kept low, and that brood lac is not purchased, and crops are successful it would be possible to make a *small* profit even at the present prices from plantation grown lac.

To produce 100 maunds of Palas lac per year, it would be necessary to have at least 3000 trees allowing for failures, resting etc. From a plantation of this size there would be Rs. 200/- available for all overhead charges annually.

It may be added that there are practically no lac plantations at the present time except those used for experimental purposes.

In the case of cultivation by an individual on his own trees not under plantation conditions, labour charges will of course be the same as under plantation conditions. The main difference being that the Rs. 2/- profit per maund referred to under plantation conditions, here does not have to cover plantation maintenance and management charges, though even under these conditions a certain amount will have to be spent on Chowkidars to prevent theft, and on supervision at pruning, infection and cropping seasons. Examples of these conditions are a Zamindar in his own Zamindary, a tenant on his own holding and a Tea Garden Manager on his garden. If the trees are rented, rent will also have to be met from the profit.

Small profits can still be made by private individuals by this type of cultivation.

The figures quoted actually refer to Palas. By cultivation of Kusum or Kusmi lac rather larger profits may be expected. The labour charges are only slightly higher for the production of Kusmi lac, and its price is Rs. 12-8 per maund as compared with Palas at Rs. 8/- per maund, at the present time. (September 1937).

It should be borne in mind that there is in addition always the risk of a poor crop or even a complete crop failure whether it be due to unfavourable

climatic conditions or other reasons. Seasons have occurred in which cultivators have not recovered the amount of brood used for infection even under the most scientific methods of cultivation. This actually happened during the Jethwi 1937 crop.

Aims of Cultivation.

The aim of the cultivator under whatever system he may cultivate should be to use the lac hosts at his disposal to their greatest advantage, and to make his area self-supporting as regards brood lac. This latter is an important point, as the purchase of brood is often expensive especially during a bad season, and may even be unobtainable if the season has been very adverse and each cultivator has enough for himself only and no more. The necessity of purchasing brood in very many cases will swallow any profits he might have made. Its sale on the other hand is remunerative. Each cultivator should evolve a plan on which he intends to use his available material, his primary objects should be:—

Importance of brood production.

1. To produce brood lac at the seasons of infection (*i.e.*, June-July and October-November, also January-February if he wishes to use Kusum).
2. To have ready for infection trees correctly pruned and treated to take the brood produced, at each season.
3. To use the trees in his area in such a way that the largest possible number are always in use.
4. To produce the largest possible amount of healthy lac, free from pest, from the trees at his disposal.

Of the lac produced the most important is that to be used as brood, as upon the brood depends the next crop, the scraped lac from it also can be sold, after use as brood. The remainder of the lac is treated in one of two ways. First, it may be sold as brood, this is the most lucrative method of sale, as brood lac fetches a better price than ordinary stick lac and is heavier as it contains not only the lac but the sticks also. It should be the aim of every cultivator to produce brood for sale and find a market for it. The other method of sale is of course to scrape it from the stick and sell it for manufacture.

Systematic cultivation.

It is impossible to evolve a scheme of cultivation unless the various host trees at the cultivator's disposal and their number is known, this therefore is the first step which must be made prior to bringing an area into cultivation. Some method must then be devised for marking the trees in order to facilitate their use. This must be left to the individual, in some cases numbering, in some cases blazing certain batches of trees, in some cases where there is natural grouping, naming or numbering the groups, will be found the most convenient.

When this has been done an outline programme can be drawn up of the manner in which the material at his disposal can be used to the best advantage.

Indiscriminate pruning and inoculation is not advised, it is improvident and does not allow use of the trees to the greatest possible advantage.

Pure and Cross Strains.

Lac can be grown in two ways. First, it may be grown for crop after crop on a given type of tree as for example Palas, this might be described as a Pure strain Palas lac. Secondly, it may be grown alternately on two different hosts, an example of this is as follows ; an area contains two kinds of host, say, Kusum and Khair. The Kusum is inoculated for the February to July (Jethwi) crop, and the brood produced is transferred to Khair for the July to February (Aghani) crop. In February the brood poduced by the Khair is again utilised to infect Kusum, and so on. This is known as a Kusum Khair alternation, and the principle as alternation. The strain is of course a cross strain.

Alternations.

Both are valuable methods of cultivation, where pure strains are grown however, it is advisable to introduce fresh brood from elsewhere at intervals to prevent deterioration and in areas where several kinds of host are available the use of alternations regular or occasional is *strongly* advised.

Records of cultivation.

In order that an idea may be formed of the success or otherwise of lac cultivation a simple record should be kept. This will be found worth while, as the records of pruning dates, amounts of brood used and yields obtained, will be found extremely helpful and valuable at a later date.

A simple register for this record of cultivation is given in Table XII. The yield has been divided into two lots, that used or sold as brood lac and that sold as scraped lac. If none of the yield is required or sold as brood it should be scraped at once, the yield figure should then be filled in the scraped lac column.

TABLE XII

Crop.....*193* .

Host.....Number inoculated.....Large / Medium / Small

Date host last pruned or cropped.....

Weight of brood used ... ... Md. Sr. Ch.

Kind of brood used .....

Swarming began on.....

Brood Removed ... ... Md. Sr. Ch.

Weight of phunki lac got back scraped ...

Date crop cut ... ...

Yield obtained ... ... *Brood lac.* / ... ... *Scraped lac.*

Brood to yield ratio .....

Costs	Rs.	A.	P.	Returns	Rs.	A.	P.
Cost of pruning (if pruning as a separate action has been carried out)				*Price obtained for phunki, from brood*			
Cost of brood (if purchased)				*Price obtained for portion of crop sold as brood*			
Cost of infection work ...				*Price obtained for portion of crop sold as scraped lac*			
Cost of removal of brood ...							
Cost of scraping phunki ...							
Cost of cropping crop yield ...							
Cost of scraping crop yield ...							
Total ...				Total ...			

A rough brood to yield ratio can be obtained by comparing the weight of brood used, with the weight of brood lac obtained before any of the yield is scraped, in this case bad and sparse encrustations should be neglected from the yield. A more accurate brood to yield ratio is obtained by comparing the scraped phunki lac from the brood with the scraped lac from the yield, where the whole crop has been scraped, or with the scraped lac from the portion of the yield not used as brood plus the scraped phunki lac from the portion of the yield used as brood after use, where part of the crop has been used as brood.

Method of designating strains.

Lac is termed after the tree on which it is grown, that is to say, lac growing on Khair is referred to as Khair lac and that on Kusum as Kusum lac. The brood lac produced also takes the name of the host, for example brood cut from a Kusum tree is called Kusum brood. In many cases however it may be convenient to refer also to the mother brood, and in alternations it is often necessary to quote the ancestry of a given strain more fully, citing the mother of the mother strain and even at times ancestry antecedent to this. For the sake of uniformity and simplicity the following method has been adopted at Namkum.

The host trees are referred to by the initial letter of their vernacular names, in cases where mistakes could arise the first few letters are used. Thus K stands for Kusum ; Kh. for Khair ; P for Palas, etc. To refer to any given lac, the brood is given first then a multiplication sign, then the host. Thus the crop produced by inoculating Kusum brood on Khair, would be written K. × Kh. When the crop is cut the brood is then termed Khair brood, progeny of Kusum and is written Kh. (prog. K) brood.

If this brood then be inoculated on Kusum, the crop will be written Kh (Prog. K) × K. This brood again inoculated on Khair will be written— K (Prog. K × Kh) × Kh and so on.

It is quite simple to interpret a symbol such as the above and the method is as follows. The letter after the bracket is the host tree in use, and that before it, the brood used for infection. The letters in the bracket represent the ancestors of the strain, the mother being at the right hand side and its mother second from the right, and so on.

Example—

Ber (Prog. P × P × Ber) × Kh.

Palas brood was originally inoculated on Palas, the brood produced was inoculated on Ber, the brood from this also was put on Ber. This inoculation yielded the Ber brood now put on Khair.

There is here a point which must be made clear, and one which must be remembered particularly while reading the following chapters dealing with

Variation in behaviour in different districts.

the use of the individual lac hosts. It is impossible to lay down hard and fast rules in nature, in one district a tree may be a poor lac host in another a good one. An example of this is Ghont, *Zizyphus Xylopyra,* a valuable lac host in Central Provinces, which planted at Namkum will not carry a successful lac crop. Also as regards resting a tree after cropping, prior to re-inoculation with lac, only general principles can be given, the behaviour of trees varies according to so many factors, many of which cannot be foreseen, and the cultivator must combine the general principles given in this book with his own common sense and experience. If a tree from which a Baisakhi crop was cut in July has given rise to long healthy infectable shoots by the following October—November by all means re-infect. If, however, the shoots are poor and short in October allow it to rest until either the following July or October. In this latter case, if the shoots have become hard and woody by March—April the trees should be repruned prior to infection.

It must be remembered that although the advice given in this book is the result of many years experience in a large number of Districts, hard and fast rules cannot be given, only the general principles which have been found satisfactory by experience. These even, may need modification in different districts under different climatic and soil conditions. The methods laid down however may be said to apply with but slight modifications, throughout the major area of lac cultivation.

Lac in Tea Gardens.

It has been stated earlier in this chapter that lac can be grown as a subsidiary crop in tea gardens. Enquiries have been received at this Institute as to whether the black sooty fungus referred to in Chapter I which will be found on tea bushes growing under lac infected trees is harmful to tea. Mr. Bates Manager of the Assam Frontier Tea Company Palandu Division in the Ranchi District has for some years grown lac on suitable shade trees in his tea gardens. His experience is that the sooty fungus is quite harmless, and does not affect the bushes, or the quality of the tea produce, adversely.

Conditions under which lac thrives.

Lac does not grow well under absolute jungle conditions, it grows best under plantation or orchard conditions, these later are however not economic at the present market prices. The majority of the lac produced is grown on trees round villages, and on cultivated or semi-cultivated agricultural land, by this is meant on trees growing in land cultivated for the production of paddy, wheat, sirguja, mustard or other agricultural crop ; on trees growing on waste land such as road side and uncultivated land ; and under semi-jungle conditions. In such situations growth is satisfactory.

The growth of lac is usually superior on trees growing in agricultural land and around villages, where the trees get a certain amount of cultivation and manuring.

It is a well known fact that during the Baisakhi crop in hot arid districts as for example Daltonganj, many trees will not carry lac through the hot

Lac and Sub-soil moisture.

weather months April—May and June to give brood lac in July. A certain percentage only of the hosts infected, varying according to the extremity of the season, will carry lac to brood in July and are therefore known as brood producers. In almost every case it is found that such trees are either growing on or close to, cultivated land, are in situations well protected from the hot winds or are in situations where subsoil moisture is to be expected. In Kundri plantation, Daltonganj, a pure stand of Palas, brood producers are commonly found in two situations, *viz.*, near cultivated land and in the neighbourhood of one or other of the big tanks in the plantation. Although these tanks dry up in the hot weather, subsoil moisture is to be expected in their vicinity.

This is further discussed in the chapter on Palas.

Subsidiary Crops.

Investigations are at present being carried out as to the practicability of growing a subsidiary crop in lac plantations as an additional source of revenue, as a green manure, and as a soil protector holding up moisture and preventing soil erosion.

Arhar, *Cajanus indicus* is showing promise in this respect, and it is hoped that Bogamedalor, *Tephrosia candida* and Soya bean, *Glycine hispida* will also be important in this respect.

The possibility of additional revenue being obtained from grasses is another point which should be borne in mind. Guinea grass, *Panicum maximum* a fodder grass and Sabai, *Pallinidium angustifolium,* used for string, mat and paper making, are being tried at Namkum. Spear grass, *Heteropogon contortus* is much used for thatching and can be used for fodder when young, the spears are however a considerable nuisance when carrying out operations in connection with lac cultivation.

CHAPTER V.

PROPAGATION AND SUBSEQUENT EARLY TREATMENT OF LAC HOSTS.

For the reasons given in Chapter IV the initiation of lac plantations is inadvisable at the present time as lac cannot be grown economically under plantation conditions. The propagation of lac hosts and their subsequent treatment is however of importance to cultivators who wish to replace mortalities in existing plantations or who wish to add to the number of lac hosts on their land in the most economical way.

Manuring. Manuring, which is of considerable value is advised only while the young hosts are seedlings and in the early stages. Once the trees become well established manuring may be abandoned, its continuation however is beneficial and will help to promote rapid growth. The object of manuring is to ensure healthy establishment and to bring the plants to a stage at which they are sufficiently developed to take a lac infection as quickly as possible.

The value of cultivation and manuring in the early stages of host growth has been well demonstrated with Khair at Namkum. Two blocks of Khair trees each $2\frac{1}{2}$ years old were compared, one had received cultivation and manure, the other had been entirely left alone. The former at that time contained tall healthy trees of some 15′—20′ high, the latter small weedy plants of between $2\frac{1}{2}$ and 3 ft. and a great many casualties (See Norris, Bates and Rangaswami 1930 Figs. I and II).

Important hosts. There is a large number of trees and shrubs which are hosts of the lac insect, of these however only a few are of major importance whilst some hosts e.g., *Zizyphus Xylopyra* Ghont are of value in given districts only. Four only are to be considered of sufficient general importance for propagation.

Schleichera trijuga	Kusum	(*Sapindaceæ*)
Acacia Catechu	Khair	(*Leguminosæ*)
Zizyphus Jujuba	Ber	(*Rhamnaceæ*)
Butea frondosa	Palas	(*Leguminosæ*)

Palas and Ber. Ber is at present hardly worth planting, it is not a lac host of any special value, and is not a valuable tree for other purposes. Palas is a good lac host but does not take well to districts to which it is not suited. In the usual way attempts to introduce Palas into districts where it does not occur are not successful. In districts where Palas does occur, it is usually plentiful ; it regenerates naturally, and protection of the young plants against grazing or cutting is usually all that is necessary to raise healthy Palas. Palas is not a tree of any particular

value other than that of a lac host though it is an important fuel tree in many areas. Both Ber and Palas can in general only be used to produce Rangeen (non-Kusmi) lac.

Kusum.

Kusum is a tree which is worth planting, on hilly or jungle land rather than in plantations. It is a valuable lac host, producing the best quality of lac and growing to a considerable size, it is a tree of general economic value, its wood is hard and is used for oil and sugar mills, rice pounders etc., the fruit is edible and the seed yields an oil (macassar) of some value Unfortunately even under ideal conditions it is a slow growing tree, and one that will not grow satisfactorily in areas to which it is unsuited.

Kusum is a large deciduous tree with a fluted comparatively short trunk and a shady spreading crown, it occurs in the sub-Himalayan tract from Sutlej to Nepal, Chota Nagpur, Central India and the Peninsula generally, throughout Burma, but is absent from Assam. It occurs in mixed deciduous forests often of a somewhat dry type, it is common on well drained boulder deposits often occurring in numbers along the sides of ravines, on sand stone and on boulder beds. It generally thrives on a light well drained gravelly or loamy soil. Natural habitat, in Chota Nagpur absolute maximum shade temperate 100°—118°F. absolute minimum 30°—60°F. normal rainfall 50"—80" or more. In Chota Nagpur it appears to favour soils from metamorphic rock containing lime. Leaf fall is from December to February, the new flush February-March. Flowers appear with the flush and the fruits ripen in June-July. *S. trijuga* is very hardy as regards frost and drought, it produces root-suckers freely. According to Troup (1921) young plants are very subject to damage by grazing. Growth is slow. Kusum is rarely gregarious.

Khair.

Khair is also a tree well worth planting; it flourishes in plantations but should for preference be planted in districts where there is Kusum available or in which Kusum is also to be grown. The reasons for this will be made clear later. Khair used in alternation with Kusum yields a lac of the kusmi type of equal value to that grown on Kusum itself, it is also a fast growing tree under suitable conditions. Khair is in addition a tree of economic value in itself, cutch and kath both being obtained by boiling down chips of its heart wood. Cutch is used in India for dyeing and tanning and is also exported, kath is used for chewing with betel-nut. The wood is used for agricultural implements, wheels, etc., it also gives excellent fuel and charcoal.

Khair is a moderate sized deciduous tree with a light feathery crown. It occurs throughout the greater part of India except in the most humid regions, it is typically found in one or other of the following situations. In shingly or sandy alluvial beds of rivers and streams which may or may not dry up during part of the year, here it is markedly gregarious. In dry forest on high land away from water courses where it is usually more or less gregarious but commonly mixed with other species. In Chota Nagpur it is found in dry

mixed forests often including sal, in its natural state it appears to favour soils containing lime. Khair is leafless from about January—February, the new flush appearing in April or May, flowers appear with the flush, the seed pods ripen during December—January. The seed is prone to insect attack, old seed seldom gives satisfactory germination. Growth is rapid. Khair does not grow well in shade, it is fairly frost hardy, it is capable of growing in dry situations but suffers severely from abnormal drought. Natural regeneration under suitable conditions is profuse, the young plants are very susceptible to grazing.

Direct Sowing.

There are two methods of propagating lac host trees from seed, *viz.*, direct sowing ; and the raising of seedlings in Nurseries, for transplantation later. Some hosts react better to the former treatment, some to the latter.

The following host trees are best sown direct: —

1. *Acacia Catechu* ... ... Khair

2. *Schleichera trijuga* ... ... Kusum.

It was originally though that Kusum should be sown in nurseries, and transplanted later, but more recent results particularly those obtained by the Bihar Forest Department, point to better growth where direct sowings were made.

Nursery Sowing.

Nursery sowing and transplanting was found to be a satisfactory system for:

1. *Butea frondosa* ... ... Palas.
2. *Zizyphus Jujuba* ... ... Ber.
3. *Zizyphus Xylopyra* ... ... Ghont.

Namkum methods.

The methods utilised at Namkum are outlined in the following paragraphs. Nursery beds were prepared at Namkum 40′ × 2½′ and dug to a depth of 9″. In Chota Nagpur at any rate it is advisable not to exceed this depth. Artificial manure was well mixed into the soil at the following rate for each bed: —

Ammonium sulphate	...	½ oz.
Potassium sulphate (or chloride)	...	½ oz.
Concentrated superphosphate	...	1 lb. to 2 lbs.

Or the trees may be manured with well rotted cowdung and leaf mould.

Transplantation.

The optimum time for seed sowing is the middle of March though seeds may be sown at other times. The depth of sowing varies with the size of seed, very small seeds should lie just below the surface, no seed should however be placed deeper than ½″—1″. Water should be given once daily until germination and then every second day till the break of the Monsoon. The young seedlings should be transplanted after the first few showers of the monsoon, if growth is very rapid earlier transplanting may be done. Seedlings should be

transplanted into circular pits 2½ ft. in depth, the soil in each pit being well mixed with manure in the following proportions:—

Ammonium sulphate	... 1 oz.
Potassium sulphate (or chloride)	... 1 oz.
Concentrated superphosphate	... 1 lb.

Pits for direct Sowing.

Well rotted cow dung and leaf mould may be substituted if chemical manure is not available. When seeds are sown direct they may be sown in pits prepared as described for seedlings when transplanted.

Sowing Kusum Seeds.

When sowing Kusum it has been found satisfactory to sow 6 or more seeds close together and allow the young plants to grow in competition with one another for some time, as this seems to stimulate growth. After a year or even two to three years, one plant will have become dominant and the remainder may be eliminated.

Direct Sowing.

In general, when sowing direct, seeds should be sown in pits prepared as previously explained, where they are intended to remain. Sowing is best done about the middle of March though seeds may be sown at other times. Three or more seeds should be sown in one pit to ensure satisfactory germination, after the seeds have germinated and the young plants become established the healthiest should be left and the others removed: seeds thus planted should be watered once daily prior to germination, and every second day after germination until the break of the monsoon.

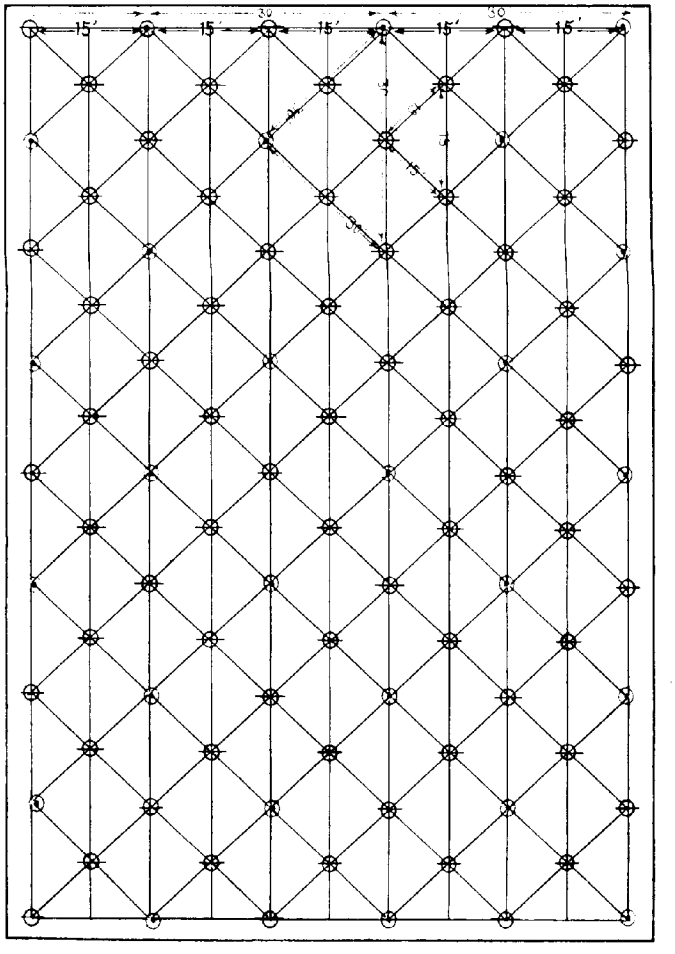
If hosts are to be grown under plantation conditions as for instance in the case of Khair, the most satisfactory arrangement of pits is equilateral spacing. The actual spacing of the pits depends upon the particular host tree.

Spacing.

The value of triangular spacing is that as the trees grow, should it be found that they require wider spacing, this can easily be accomplished. Alternate rows are cut down, and alternate trees in the standing rows are also felled, this leaves the remainder triangularly spaced at double the previous distance. Actually before it becomes necessary to increase the spacing, at least two or three lac crops will have been taken from the trees to be felled: in this way the most economical use of space and time is made. Text Figure 1 represents a plantation set out on 15 ft. triangular spacing, if after some years the trees are found to be too crowded, those shown by black circles can be felled, and the trees remaining will then still be triangularly spaced but now at a distance of thirty feet.

The following is the spacing used at Namkum for the more important lac hosts:—

S. trijuga (Kusum)	... 20′
A. Catechu (Khair)	... 15′
B. frondosa (Palas)	... 12′
Z. Jujuba (Ber)	... 15′
Z. Xylopyra (Ghont)	... 15′



TEXT FIGURE I.

Plantation Lay out ; Triangular Spacing.

As regards subsequent treatment, cultivation round young plants should be carried out to about 1 yard radius and 9" depth, and where practicable water can be given, once or twice a week until the break of the second monsoon, where impracticable water should be given to the young plants once or twice a week during the months April and May, if they show signs of wilting. **Subsequent treatment.** **Watering.**

Manuring of the young plants though not essential will be found to be of great value in increasing their speed of growth and bringing them to a stage suitable for infection in the shortest possible time. A suggested manuring which was found useful at Namkum was the following:— **Manuring.**

	Per plant.
Potassium sulphate	... 1 oz.
Ammonium sulphate (or chloride) ...	... 1 „
Concentrated superphosphate ...	... 1 lb.

The manure should be dug into an area about 1 yard radius and a depth of 6"—9" round each plant. April-May is a suitable time for application of manure. Other manures such as Ammaphos, or Nicifos which is easier to apply than Ammaphos as it does not tend to lump, or well rotted cow-dung may be substituted for the above.

Where soil analysis shows a deficiency in calcium, lime may be given; at Namkum and Kundri, calcium deficiency was made up by liming at a rate of 1000 lbs. per acre. In Chota Nagpur, a shortage of lime is to be found in many districts, liming however is inadvisable as the addition of lime neutralises the already only slight acidity of the soil, as most trees require a slightly acid soil for satisfactory growth, the neutralising of this acidity is harmful. Liming is for this reason not advised in Chota Nagpur. **Lime.**

Water logging of young seedlings should be avoided as this is a common cause of mortality, particularly in the case of Khair. The plants may be banked up prior to the Monsoon and if water logging occurs temporary channels should be cut to run the water off.

During the remainder of the year every effort should be made to conserve as much water as possible on the land, either terracing or contour ridging are valuable for this purpose where the land is not level. **Conservation of moisture.**

Very considerable improvement was observed in the Forest Department plantation at Mako Latehar as result of moisture conservancy due to contour ridging.

Age from seed at which plants can be lac infected.

At Namkum the major lac hosts were sown using the methods outlined in order to discover at what age from seed it would be possible to infect them with lac. These ages apply to plants grown under plantation conditions and manured annually.

1.	*S. trijuga* (Kusum) ...	... 6—8 years.	
2.	*A. Catechu* (Khair) ...	... $2\frac{1}{2}$—3 ,,	
3.	*Z. Jujuba* (Ber) ...	... 3—4 ,,	
4.	*B. frondosa* (Palas) ...	... 5 ,,	(Grows very slowly at Namkum on the Ranchi plateau, to which it is not well suited).
5.	*Z. Xylopyra* (Ghont) ...	... 3—4 ,,	(Ghont is not a lac host in Bihar).

Root and shoot cuttings.

Ber may in some districts be found regenerating naturally and where Ber seedings are available, they may be transplanted and replanted, where desired, by taking root and shoot cuttings, as follows. The seedlings should be dug from the ground and the root system pruned at a depth of about 9", the stem above ground should then be shortened to 6"—9". Seedlings thus treated may be planted in pits and will take satisfactorily. This may also be done with Khair, which regenerates freely in plantations, and also *Acacia Farnesiana.*

Propagation of Ficus sps.

For the propagation of *Ficus sp.,* the planting of large cuttings is rapid and satisfactory. Cuttings may be as long as 4'—5' and be as much as 1"—2" in diameter, or even more. Cuttings should be well set in *unmanured* pits to a depth of about 2' 6" and the soil well rammed down round them. Manure if desired may be given later when roots have had a chance to form.

The following *Ficus sp.* have been grown from cuttings:—

Ficus glomerata (Dumber, Gular).
Ficus infectoria (Pakaur).
Ficus glabella (Putkul).
Ficus religiosa (Pipal).

Manuring and the Lac Insect.

It is of course obvious that since the lac insect is obtaining the whole of its nourishment from the tree on which it is growing, any factors which tend to increase and benefit the growth of the tree will affect the insect beneficially. At Kundri a study of wax and resin secretion by the lac insect grown on *Butea frondosa* (Palas) showed that manuring of the host plants resulted in a greater output of lac.

The reason for manuring is as follows, the tree requires for its nourishment 15 elements, these are:—

1. Carbon.	6. Phosphorus.	11. Chlorine.
2. Nitrogen.	7. Sulphur.	12. Aluminium.
3. Hydrogen.	8. Calcium.	13. Silicon.
4. Oxygen.	9. Sodium.	14. Manganese.
5. Potash.	10. Iron.	15. Magnesium.

Reasons for Manuring.

Of these carbon and oxygen are obtained from the air and hydrogen and oxygen from the water which the roots absorb from the soil. The remainder must come to the plant dissolved in the water which it absorbs *via* the roots. Growing plants drain the soil very heavily of nitrogen, potash and phosphorous the remainder need not be considered in a general account, except calcium. In order to keep the plant well supplied with nourishment so that growth is continually at a maximum, the elements that are drained from the soil must be replaced, this is particularly the case with trees in use for lac cultivation, because the actual presence of the lac insect feeding on the sap increases the drain that the tree makes on the soil. Constant pruning and crop cutting, stimulating as it does increased growth activity also increases food requirements. Manuring therefore is beneficial in lac cultivation. *The cost of manuring must however be set off against the increase in resin produced, as unless there is an adequate return for outlay no cultivator will purchase chemical manures which are admittedly costly. At the present prices prevailing in the lac market manuring is definitely not to be recommended, although the use of manures is beneficial both to insect and tree.*

Manuring not economic at present prices.

The use of organic manure such as cow-dung, fish waste etc. is advised where these materials are available cheap. Their purchase at the present prices of lac would not be economic.

If however it is decided to carry out manuring, it is advisable to have a soil analysis of the area made, to discover what elements are lacking or depleted. A manurial programme can then be drawn up specially adapted to the area concerned.

Types of Manure.

Nitrogen is supplied by animal dung, night soil, green manure, leaf mould, oil cake, sodium nitrate, ammonium sulphate, calcium cyanamide.

Phosphorus by bone meal, fish waste, concentrated superphosphate ; the two former supply some nitrogen also.

Potash is supplied by ashes, and potassium sulphate, or potassium muriate, (Potassium chloride) the muriate being the cheaper of the two.

Green Manuring.

Green manuring is carried out by sowing a field cover crop, broadcast in the area containing lac hosts. The crop chosen is generally *Leguminous* owing to the power of this group to obtain nitrogen by fixation. Such crops should be sown in June in the early showers of the monsoon, and ploughed

or dug into the ground when about $\frac{1}{3}$rd the crop is in flower before the stems become woody; at this time their effect is the most beneficial. Alternatively they may be allowed to seed and the seeds collected before they are hoed in. They are a large number of cover crops which may be used in this way, among these are *Cajanus indicus* (Arhar), *Crotalaria juncea* (Sun Hemp) and *Dolichos sinensis* (cow pea). See also Chapter IV.

Leaf mould.

Leaf mould is a valuable manure and in many districts universally available for the trouble of making it. The following account of how to prepare leaf mould may help to increase its use:—Leaves, grass, dead green plants etc. should be collected and thrown into a deep pit dug for the purpose where they are allowed to decay. This process may be accelerated by occasional soaking with water in the hot weather. The pit when full may be earthed over and left and the manure should be ready about 1 year to 18 months later.

Karunj.

Karunj cake is a manure having a certain amount of value, it is also useful in that it is repellent to white ants.

Conditions under which lac is grown.

Lac is very largely produced in cultivated land, or in land which although not cultivated is not jungle. In general lac does not grow well under absolute jungle conditions. Plantation and orchard conditions are ideal for lac cultivation but practically no lac however is grown under these conditions as it would not be economic to do so at prevailing market prices.

The value of a certain amount of cultivation work may be seen by comparing the lac produced on hosts such as Palas and Ber growing on paddy bunds, in and around villages and on land utilised to produce an agricultural crop where they get a certain amount of cultivation and rough manuring, with lac produced on trees growing under jungle or semi jungle conditions. (For further discussion see Chapter IV).

Cost of establishment of plantations.

A rough idea of the cost per acre of establishing lac hosts may be gained from the following figures, which are very approximate. They apply to hosts which are sown in Nursery Beds and then transplanted. For direct sown hosts a deduction may be made of the amount allowed for Nursery Work.

1st Year.	Rs.	A.	P.
Making Nursery and sowing seed	4	0	0
Making pits and transplanting	27	0	0
Manuring including labour and manure ...	2	0	0
Cultivation	4	0	0
Watering	6	0	0
Total	43	0	0

Or roughly Rs. 50/- per acre, the actual cost depending on the labour charges, manure used, and amount of watering found necessary.

In subsequent early years, some watering manuring and cultivation will probably be found necessary. The cost may be estimated at

Subsequent Years.				Rs.	A.	P.
Manuring	...	...	...	2	0	0
Cultivation	...	...	...	4	0	0
Watering	...	...	...	6	0	0
		Total	...	12	0	0

Say Rs. 10/- to Rs. 12/- per acre. This cost will decrease annually as the trees become established and watering, manuring and cultivation are either greatly reduced or stopped.

These estimates do not include fencing, nor do they include clearing the land to be used. Clearing land costs about Rs. 4/- per acre. These figures do not include supervision charges.

If fairly full manuring and cultivation are to be given, the figures Rs. 2/- and Rs. 4/- in the above estimates should be increased to about double the former even more probably.

The dates at which lac hosts reach an infectable age are given earlier in this chapter.

CHAPTER VI.

PRUNING (AND CROPPING) LAC HOSTS.

Importance of pruning.

The age at which it was found possible to give hosts grown from seed at Namkum their first lac infection is given in the previous chapter. These young hosts were not pruned prior to infection. In other cases however pruning is necessary before infecting a host tree with lac if a really satisfactory crop is to be obtained.

Pruning and cropping are extremely important in that upon correct pruning and cropping depends the production of new shoots and upon the new shoots depends the lac crop. Also dependent upon correct pruning and cropping is the general health and growth of the host tree and the resting period necessary before it can be inoculated or reinoculated with lac.

In many cases as will be explained later the removal of lac from an infected tree, which is known as reaping or cropping, may be used to act as a pruning for the next crop, no repruning benig necessary. The advice in this chapter applies therefore not only to pruning but also to cropping lac host trees. *Pruning and cropping are in fact identical.*

The reason for pruning prior to infection is that the young lac larvæ prefer young succulent shoots on which to settle and feed. They are unable to feed on old branches on which the bark has become dry and hard, because their proboscides are unable to pierce the bark and reach the sap carrying tissues. In order therefore that the host trees to be used for infection shall have the maximum number of young succulent shoots in suitable condition for colonisation by the lac larvæ pruning must be done in the correct way at the correct time. Unpruned trees can of course be infected with lac, the larvæ however settle only at the periphery where the young shoots are to be found, and on some of the younger of the unpruned branches which do not admit of maximum colonisation and support; the result is a partial or poor crop only, depending on the condition of the trees utilised.

In an emergency Kusum can be satisfactorily infected unpruned, this is due to the large bowl or crown and the consequent number of young shoots at the periphery. The resulting crop is of course small in comparison to that which the same tree would have yielded after proper pruning. The infection of Ber or Palas unpruned is less satisfactory.

Method of pruning.

When either pruning or cropping the following points should be borne in mind.

1. The general health and strength of the tree must be maintained.

PLATE III.

Zizyphus Jujuba (Ber) pruned prior to lac infection.
Note young shoots coming out.
Namkum, Bihar.

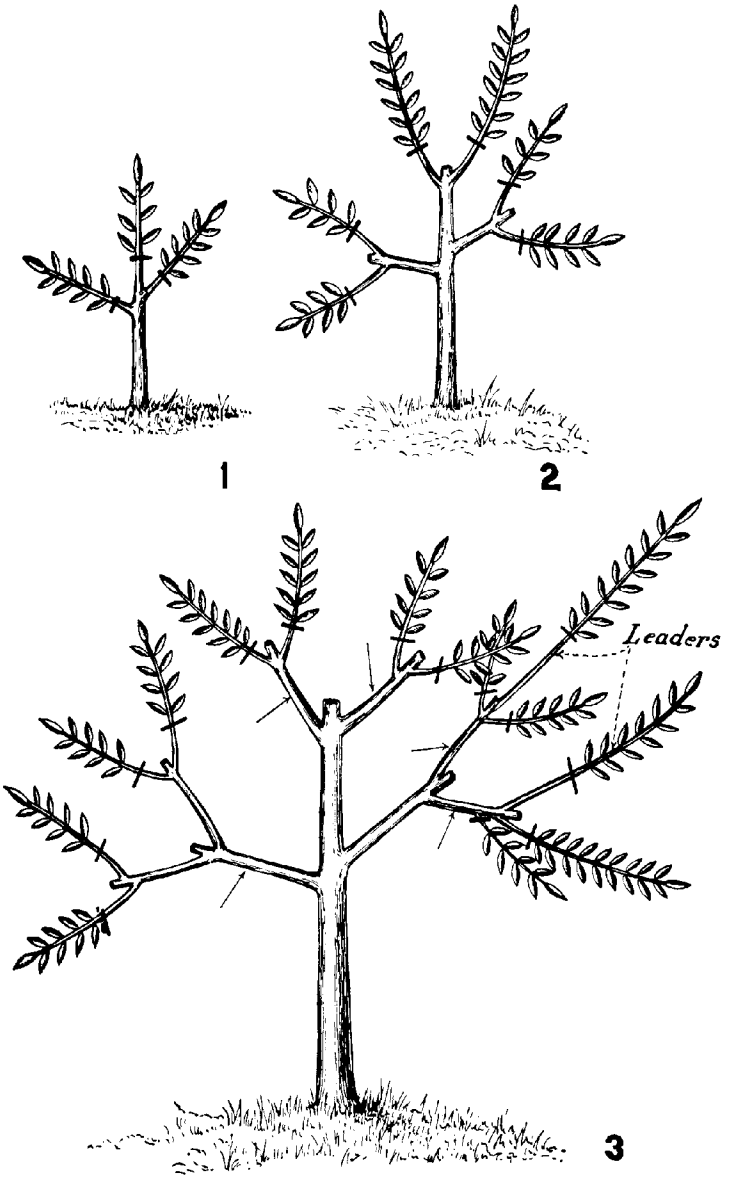


FIGURE II.

Diagramatic figure representing the successive prunings of a lac host. Red lines indicate the pruning cuts advised.

1. Original pruning.
2. New shoots resulting from the pruning shown in 1. Pruning cuts to be made at the next pruning.
3. New shoots resulting from the pruning shown in 2. Pruning cuts to be made at the next pruning.

The arrows in 3. indicate the points at which brood sticks should be tied.

2. Cutting should be done in such a way as to keep the good shape of the tree and to allow plenty of room for the growth of new shoots.

3. Branches of over 2″ in diameter should not be cut, except when pruning old trees, when it is desired to produce new wood at the expense of old, or when it is impossible to climb or reach further on the branch concerned, which rarely occurs. In the general way the most satisfactory results are obtained by cutting at a thickness of $\frac{3}{4}$″ to 1″ in diameter.

Thin branches under about $\frac{1}{2}$″ in diameter should be cut close to the branch or trunk from which they arise, the thinner they are the closer they should be cut.

When cropping, lac bearing branches must never be hacked through indiscriminately close to the main stem to save time and trouble, trees should be cropped exactly as if they were being pruned which is in fact what is being done to them.

Dead and diseased branches should be removed, split or broken branches should be cut below the split or break. When pruning or cropping trees which have previously been pruned or cropped, the cuts should always be made on the *new* wood resulting from the last pruning or cropping, the length of new wood to be allowed will depend on the thickness of the new growth ; the cut should be made at $\frac{3}{4}$″—1″ thickness and the longer the new growth that can be left the better: cuts should never be made on the old wood (i.e.) below the old pruning cuts. An exception to this rule must be made, if a number of weak shoots only arise from the pruning cut, here the cut must be made on the old wood. Pruning the weak shoots will give rise to a stag head. In this way the tree increases in size and frame with each pruning, this is beneficial to the tree and also to the cultivator as the tree being larger in frame is capable of carrying a larger lac crop when next infected.

This method of pruning and cropping is diagramatically illustrated in Text Figure II. Fig. 1 represents a young host tree, with a main trunk from which three main branches arise, the pruning cuts should be made at the positions shown by the red strokes, the thickness at these points being about $\frac{3}{4}$″—1″ in diameter. The response to this pruning is illustrated in fig. 2. and the tree is inoculated with lac as explained in the following chapter. When the crop is reaped the cropping cuts should be made in the positions shown by the red strokes which it will be clearly seen are on the new wood which has arisen from the last pruning. The response to this cropping is illustrated in fig. 3. and the tree is again inoculated with lac, the cropping cuts which will be made when this crop is reaped are again shown by red strokes.

The actual position at which the cut will be made on the new wood will depend on the vigour and thickness of the new growth, the thicker the growth the more will be left below the cut. It should be cut at a thickness of about

$\frac{3}{4}$"—1" and if less than $\frac{1}{4}$"—$\frac{1}{2}$" in diameter should be cut close to its origin, or left. This is illustrated at the right side of the tree illustrated is Fig. 3. The most vigorous growth may be termed the leader and should be encouraged as much as possible.

It must be understood that these illustrations are diagramatic, one, two, three or more shoots may arise from each pruning cut where for the sake of simplicity two are shown here.

This description and the diagrams are not intended as hard and fast rules of pruning but should be considered as the principles on which all pruning and cropping operations should be based. The actual method to be used will depend on the particular host tree, its condition and even on its individual growth.

Pruning of large fully grown trees should be done in exactly the same way. Settlement of lac larvae will occur on the finer more succulent twigs towards the periphery of the bowl or crown and the object is to produce the greatest number of shoots in this region. Text Figure III illustrates diagrammatically a large Kusum tree, the correct pruning cuts are marked with red strokes. The branches cut should not be less than about $\frac{3}{4}$" in diameter or more than 1" to 1$\frac{1}{2}$" in diameter.

The raiyat method of pruning Kusum, and other trees also, is to cut through much larger branches than those recommended in this book. In Text Figure III the cuts as would be made by the average raiyat are shown in green lines.

Pruning in this way is most harmful and must never be permitted.

Reasons why heavy pruning is to be depreciated.

There are a number of very good reasons why this heavy type of pruning often used by the raiyat is to be depreciated. These are:—

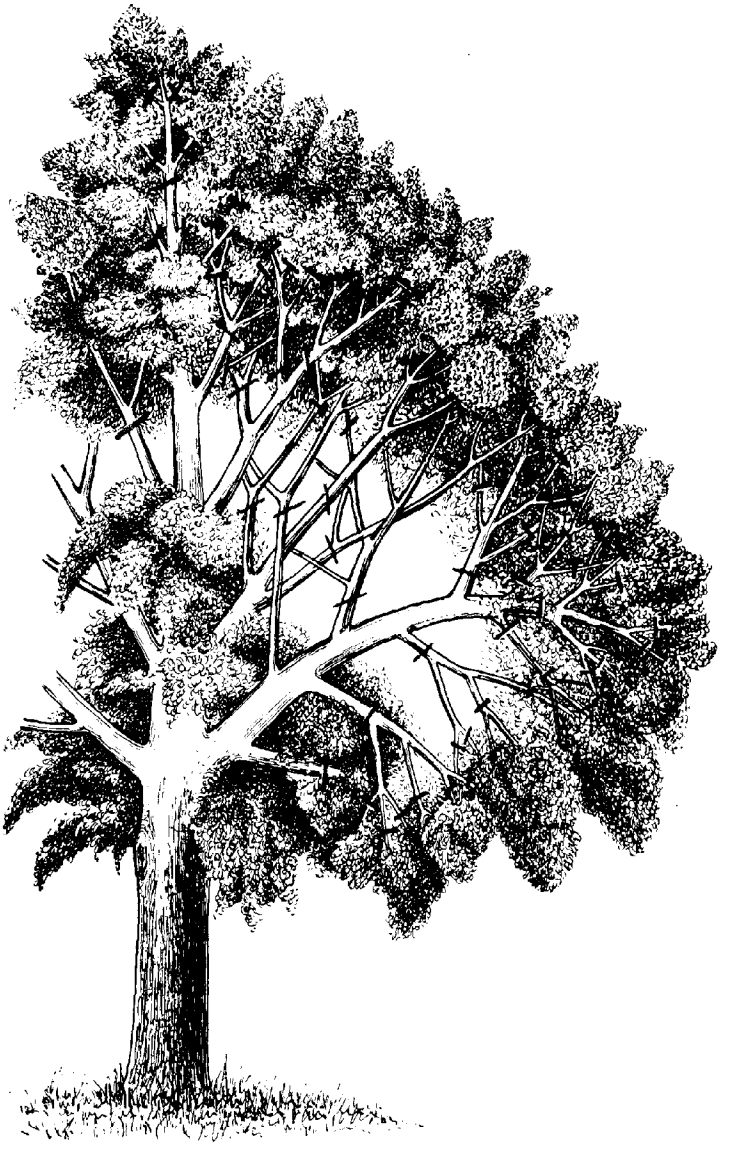
1. Pruning in this way is extremely harmful to the health of the tree.

2. The actual frame of the tree is not only prevented from increasing in size but is actually reduced.

3. The time taken for the tree to recover after pruning and to throw out shoots suitable for infection with lac is very much longer when this heavy type of pruning is used than when the methods here advocated are employed.

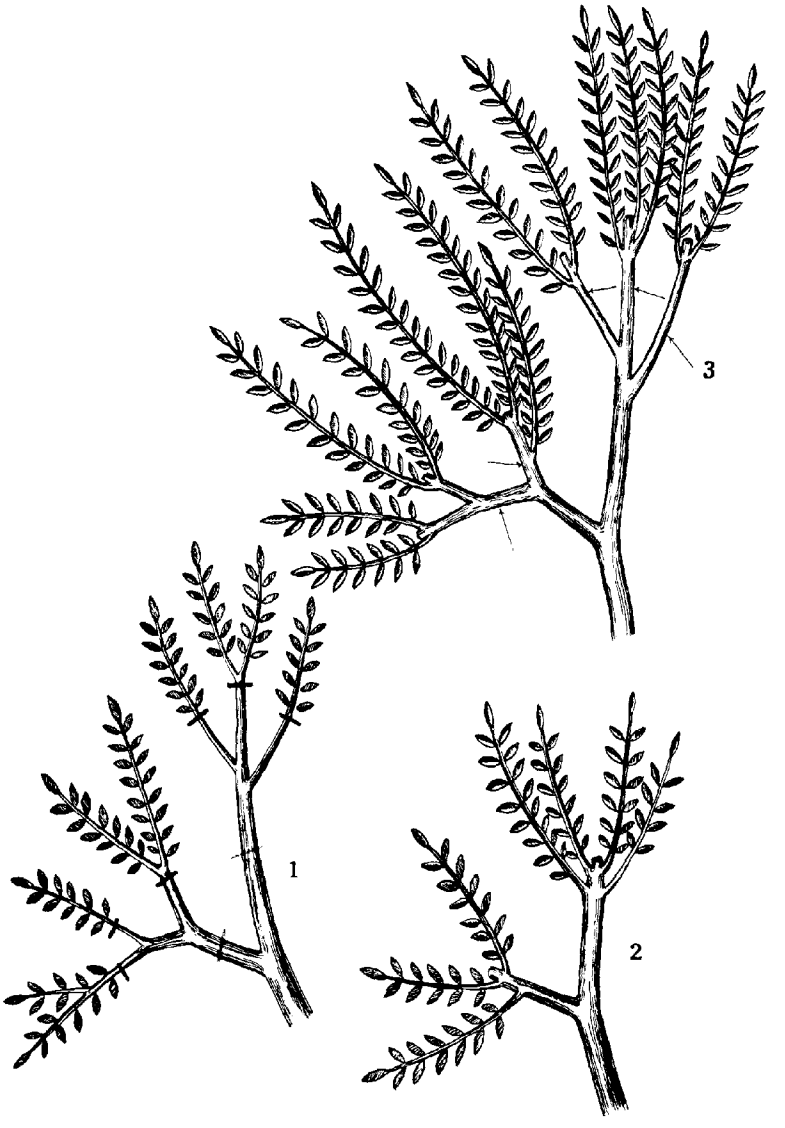
An example of this may be cited; a Kusum pruned by the raiyat method must be rested for 2-3 years before it can be infected with lac, whereas pruned by the Namkum method the tree may be utilised as a lac host 1 year to 18 months later.

4. Fewer infectable shoots are produced by heavy pruning than by light pruning. This is clearly illustrated in Text Figure IV.



TEXT FIGURE III.

Correct and Incorrect method of pruning a Kusum tree (diagramatic).
Green Lines. *Incorrect.* Indicate the cuts usually made by the raiyat.
Red Lines. *Correct.* Indicate the cuts advised by this Institute.



TEXT FIGURE IV.

Diagramatic figure showing the shoots resulting from *Heavy* and *Light* pruning.

1. Pruning cuts. *Incorrect* cuts shown in Green
   Correct cuts shown in Red.
2. Shoots resulting from too heavy pruning. Note the small number of new shoots.
3. Shoots resulting from correct pruning. Note the relatively larger number of new shoots.

The arrows in 3, indicate the points at which brood sticks should be tied.

As regards when to prune, the general broad rule, in Bihar to which there are however many exceptions, is prune in March-April for infection in July, and prune in April-May for infection in October-November. The use of a crop cutting as a pruning will be explained fully under detailed instruction as to the use of the several lac hosts. **Correct time to prune.**

The following account outlines the pruning dates for trees which are being used for the first time as lac hosts, or which have not been lac infected for some time, or require repruning after having been cropped. The times of pruning are those generally found satisfactory, but must not be taken to apply exactly in every district.

Kusum should be pruned either in February or in July and at no other time. The former season is the better of the two. Kusum takes some time to recover and throw out fresh shoots, and when pruned by the raiyat method requires 2-3 years rest after pruning. When pruned by the method here outlined Kusum may be infected with lac 1 year to 18 months from the date of pruning, (when utilised in conjunction with Khair as explained later Kusum should be used 18 months after the date of pruning). **Pruning Kusum.**

Crop cutting being done as it is in February and July can always be utilised as a pruning in the case of Kusum and trees thus cropped may be reinfected 1 year to 18 months later, provided the methods here explained are followed.

Cutting should be done at a thickness of $\frac{3}{4}$"—1".

Khair.

Khair should never be infected with lac at any time other than July. For July infection Khair should be pruned in March. This host does not suffer heavy pruning well and should be pruned as explained in this chapter. February crop cutting acts as a pruning and the trees can be reinfected the July following. **Pruning Khair.**

Cutting should be done at a thickness of $\frac{3}{4}$"—1".

Ber.

Should be pruned in March-April for infection in July and in April-May for October-November infection. It is able to withstand rather heavy pruning, the methods advocated however will yield better results than very heavy pruning. Cutting should be done at 1" to $1\frac{1}{2}$" thickness. Ber should be pruned rather more heavily than either Khair of Kusum. For infection with Kusum brood Ber should be pruned 15 months before infection. **Pruning Ber.**

Palas.

In the general way Palas is not usually infected artificially with lac in July for reasons explained later, where July infection is to be done, pruning **Pruning Palas.**

should be carried out in April. For October-November infection, the season of major importance for Palas inoculation, the trees should be pruned in May. Palas can and does stand drastic treatment and should be more heavily pruned than Kusum or Khair, shoots should not be cut above the part that has become woody. Branches should be pruned at a thickness of about $1\frac{1}{2}$"-2" in diameter, branches thicker than this should not be cut.

Pruning Ficus sps.

Ficus sps.

In general should be pruned in April for July infection and in May for infection in October.

Pruning instruments.

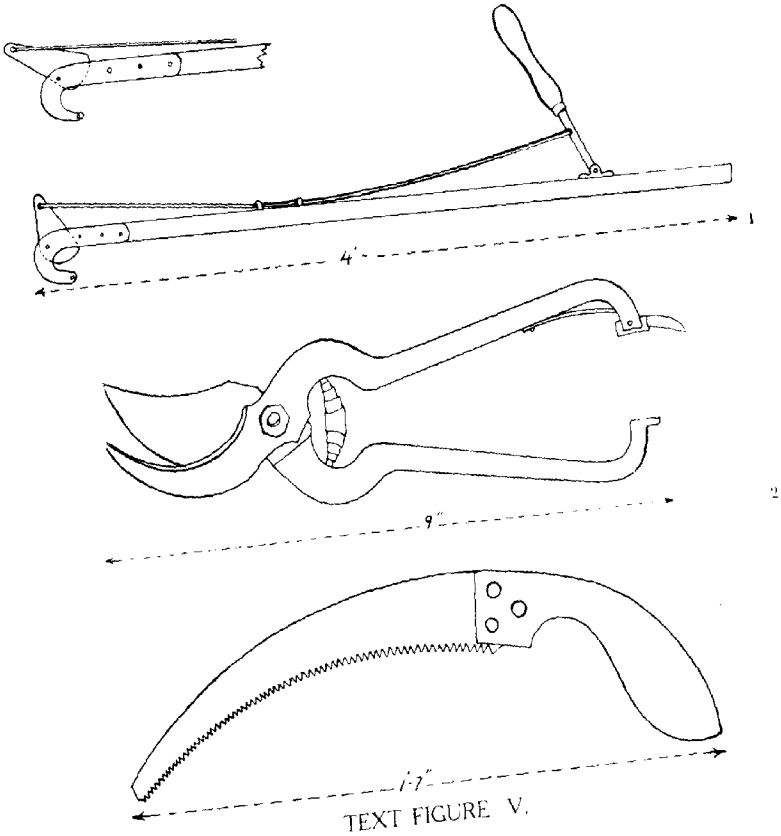
The majority of raiyat pruning is done with axes (taungis) and this may explain to some extent the thickness of the branches cut. Proper pruning *cannot* be done with an axe, if branches of the thickness recommended here are cut with axes they will either break or split.

The ideal pruning instruments are secateurs and long handled tree pruners both illustrated in Text Figures V and VI. Of these the most valuable are the long handled tree pruners. They can be obtained from T. E. Thomson & Co. Ltd., P.O. Box 193, Calcutta, at a cost of Rs. 6/- each (spare blades Rs. 1/2/). This type of pruner as will be seen from the sketch is extremely simple and could easily be made by any village blacksmith if he had a sample to copy. In the Ranchi District 10' pruners were made at Sabaya at Rs. 2/8- each and 7' ones for Rs. 2/- each, from scrap material available. Pruners were made in Chaibassa at a cost of Rs. 3/- each. There is little doubt that a village blacksmith could make these pruners very much more cheaply. The blade must however be made out of *mild* steel, otherwise it will rapidly wear out and require replacing.

There are two types of secateurs, both obtainable from the above firm. These are the 'Rol cut' secateur and the 'French' secateur, illustrated in Text Figures V and VI and costing Rs. 5/8- and Rs. 2/12- respectively (spare parts can be obtained). The former are much the better and easier to use, but are rather easily damaged by careless use. On the whole therefore if secateurs are to be used by untrained coolies the 'French' secateurs are to be recommonded.

With the above instruments the greater part of all pruning and cropping operations on Kusum, Khair and to a large extent Ber and Palas should be done.

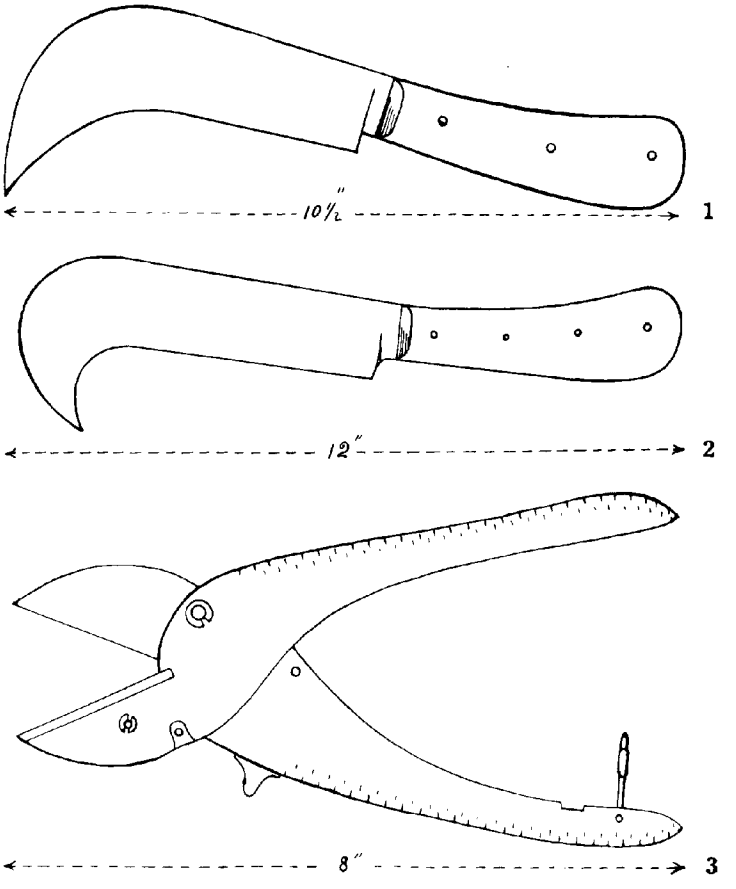
Where such pruners are not available and cannot be obtained, pruning may be done with a small sharp knife with a slightly curved blade; cf. fig. while not so good as the pruners here recommended fairly satisfactory pruning can be carried out with such instruments, provided they are kept sharp and are used properly. Such knives are illustrated in Text Figure VI and can be obtained from T. E. Thompson & Co. for Rs. 20/- to 25/- per dozen. They can however be made very cheaply locally.



TEXT FIGURE V.

Pruning Instruments.

1. Long-handled tree pruner.
2. "French" pattern Secateur.
3. Pruning Saw.



TEXT FIGURE VI.

Pruning Instruments.

1 & 2. Pruning knives.
3. "Rol-cut" pattern Secateur.

When pruning Palas and to a less extent Ber which require heavier pruning and when it is necessary to cut through thick branches as it occasionally is, either because the branch is dead or diseased, because it requires heading back, or because it is impossible to reach any further, the villager's axe or taungi should *not* be used. For this work a large sharp knife of the type of the Assam Dhaw (T. E. Thompson Rs. 1/2-) should be used. Knives of this type are easily and cheaply made locally. Another suitable instrument for this work is the pruning saw, (cf. Text Figure V) such saws can be obtained from T. E. Thompson & Co. Ltd. at a cost of Rs. 3/- each.

Cropping infected trees.

When cropping an infected tree, it will sometimes be found that the lac encrustation continues right down to the point of origin of many of the thinner shoots and even of some of the thicker ones. Where the shoots are thin $\frac{1}{2}$" in diameter or less they may be cut at their point of origin. Where the shoots are thick, over $\frac{3}{4}$" in diameter, the shoot should not be cut at the base but 2" to 6" or more of new growth should be left, according to the thickness of the shoot. The lac on the piece that is left will generally be sparse and the future health and strength of the tree is of far greater importance than the loss of a very small quantity of lac whose monetary value is negligible. The lac may be broken by hand from these places if desired.

Young trees.

The thickness advised for pruning purposes refer in all cases to well grown trees. If small young trees are being cut lighter pruning must be done.

CHAPTER VII.

INFECTION OR INOCULATION OF LAC HOSTS.

The method by which the lac insects are introduced on to a lac host is known as infection or inoculation. The times when inoculation is carried out, have been recorded in Chapter I. They are three and are as follows:—

Infection Seasons.

1. *June-July.*

   (a) Inoculation of trees other than Kusum with brood from the Baisakhi crop to initiate the **Katki** crop.

   (b) Inoculation of Kusum or other hosts with Jethwi brood to produce the **Aghani** crop.

2. *October-November.*

   (a) The inoculation of trees other than Kusum with brood from the Katki crop for the **Baisakhi** crop.

3. *February-March.*

   (a) The inoculation of Kusum and rarely other hosts with brood from the Aghani crop for the **Jethwi** crop.

Condition of trees to be infected.

The trees to be infected should, if they have been correctly pruned or cropped, be covered with healthy long succulent shoots in suitable condition for lac infection.

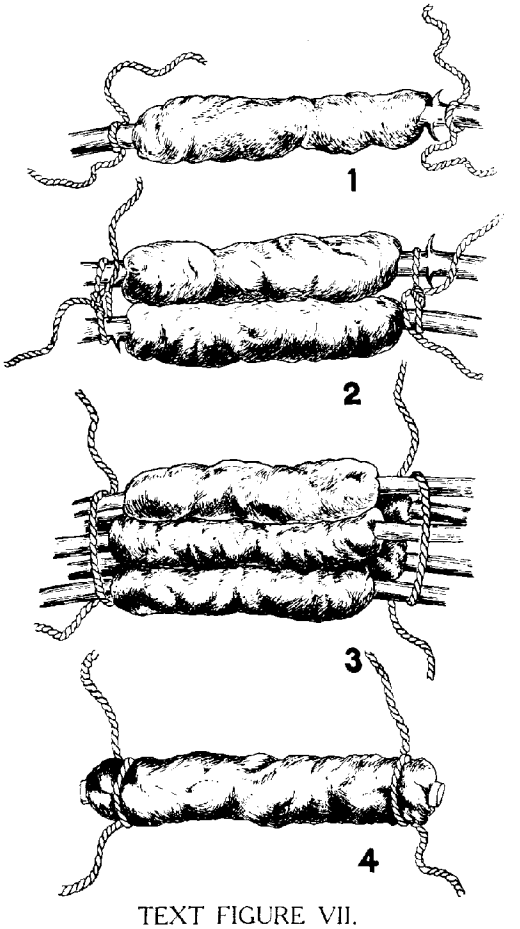
Here it should be mentioned that the cultivator must to some extent use his own judgment. If his trees bear long healthy shoots, he should infect them even if they have been repeatedly used as lac hosts in the past. If however he sees that some of the trees have put out poor short shoots only, and are not really in suitable condition for infection, these should not be infected, whether they have previously been infected or not.

Artificial Infection.

The practical procedure at the three periods of infection is identically the same and the following instructions apply to each. Artificial infection will be explained first, as this is the more general method, natural infection having a definitely restricted use.

Selection of brood lac.

The brood lac to be used for the infection of the new trees should first be examined, whether it has been grown by the cultivator or purchased by him from elsewhere. All unhealthy and pest infected sticks should be rejected for brood purposes and the lac immediately scraped from them. Healthy, non-pest infected lac should be selected for use as brood.



TEXT FIGURE VII.

Method of tying brood lac preparatory to infection.

1 and 4. Method of tying single brood sticks.

2. Two brood sticks tied together.

3. Bundle of brood sticks.

The recognition of healthy brood lac is not easily explained on paper, it can rapidly be acquired by experience. **Recognition of healthy brood lac.**

In good brood lac the encrustation is thick and continuous or semi-continuous, whereas in poor brood the encrustation is generally thin and sparse and there usually are a number of isolated cells.

Lac which shows the characteristic signs of bad damage by *Eublemma amabilis* and *Holcocera pulverea* should be avoided when selecting brood. These signs may appear as tunnels covered over by webbing or as "domes" and sometimes as small circular holes in the lac encrustation, if these are numerous the lac is badly affected and should be discarded.

It is also a good thing to break open the encrustation of some sample sticks from among the lac, if many of the honey-comb like spaces are very small or are found to contain a dry red body, the lac is not healthy and should be discarded. The spaces should be fairly large and contain a globular red body, which when crushed should give a granular red fluid, this is a sure sign that the females themselves are healthy.

Should the breaking open of the encrustation reveal predator larvae and pupae in large numbers the lac should on no account be utilised as brood.

Frequently in any given sample of lac, part is healthy and part unhealthy, of course the whole sample need not be discarded. In such cases healthy lac should be selected for use as brood and the unhealthy lac discarded. The latter should be scraped at once (cf. Chapters VIII and XIX).

The branches and twigs selected should then be cut into convenient length usually 6″ to 1′, and then tied with string. A piece of string about 6″-8″ in length is tied at each end of the stick so that at each end there are two free pieces of string 2″-3″ long by means of which the brood can be tied to the branches of the host tree. Sticks may either be tied singly, in small bundles of two to three sticks each, or in larger bundles (cf. Text Figure VII). **Tying of brood.**

The brood sticks can be tied to the tree either longitudinally or laterally, the former being the better of the two, or they may be roughly interlaced among the host branches. **Methods of infection.**

In longitudinal infection the brood sticks are tied along the host branches so that they touch them throughout their length. The brood stick should be tied at the base of a branch on the lower surface, using the string at each end to secure it. This method allows maximum contact between brood and host and facilitates the passage of the young larvae from one to the other. **Longitudinal Method.**

In lateral infection the brood sticks are tied across the gap between two new shoots or between two branches; in this way the brood stick forms a sort of bridge between the two branches, one end touching one branch the other **Lateral Method.**

end touching another branch. This method is not as satisfactory as the longitudinal, first because the area of contact between brood and host is small, being confined to the two ends of the brood sticks only, and secondly because wind and rain may cause the two branches to pull apart, and drag the string, so that the ends of the brood stick are no longer in direct contact with the host branches, connection being made only by a short length of string, across which the larvae must go to reach the host. This means considerable delay in the larvae reaching their new host and may mean a great loss of larvae in addition.

Interlaced Method.

Interlacing is useful in certain cases, in which the new shoots from pruning arise in a close group from the mother branch. If these shoots are short and do not require a brood stick each, one or more sticks of brood may be interlaced between them at their points of origin. This is a method to be used where convenient, particularly when labour is scarce, and may be used in conjunction with either of the other methods. In this method the brood sticks are not tied with string usually, although in some cases they may be roughly tied. Where brood has lateral branches arising from it at an angle as in the case of Palas, it is often merely hooked on to the host branches by the forks. These methods are useful where large numbers of trees are to be infected quickly and cheaply but are admittedly not as satisfactory as longitudinal infection.

Yet another method is to tie the brood to the host branches as in the longitudinal method, but by one piece of string tied round the middle part of the brood sticks instead of by two pieces of string one at each end.

It should be understood that cheap bazaar sutli may be used as string for this purpose and that string may be substituted by sabai or other grasses if these are cheaper and more convenient.

Bamboo, Gauze or Leaf Baskets.

When all the brood sticks have been tied a number of pieces of broken lac and many short sticks of lac will probably be left over. These may be sold for manufacture, or if brood is scare, they should be collected and placed in rough bamboo, or wire gauze baskets or even in containers made out of two leaves stitched together by short pieces of thin stick. These containers should then be tied to the host trees. These small pieces of lac will give rise to large numbers of larvae.

Whatever method is used the point of major importance is to see that the maximum contact possible occurs between brood and host, and that the brood is firmly attached to the host tree, in such a way that wind or rain are unlikely to loosen or dislodge it.

Where brood should be tied.

The brood should be tied as near as possible to the branches on which the young are to settle. The optimum position is either along the mother branch from which a new shoot or shoots have arisen after pruning or cropping, or if the shoots are particularly long and healthy, along the base of the new shoots themselves. These positions are indicated in the diagramatic Text Figures II and IV.

PLATE IV.

Zizyphus Jujuba (Ber).
Showing longitudinal infection. Arrows point to brood sticks
Namkum, Bihar.

PLATE V.

Zizyphus Jujuba (Ber.)

Showing lateral infection. Arrows point to brood sticks.
Namkum, Bihar.

When infecting large trees it is sometimes impossible for the coolies engaged in infection work to climb to the uppermost crown of the tree or out to the ends of the lateral branches. In these circumstances a bundle of brood sticks should be tied at the point beyond which it is impossible to reach. The number of sticks to be included in the bundle will depend on the number of young infectable shoots arising beyond this point; the greater the number of infectable shoots the more the brood sticks that should be included in the bundle. **Bundles of brood.**

An extremely important point arises out of this at once; how much brood lac should be reserved or bought to inoculate a given area containing lac hosts? The first step is to ascertain the number of lac hosts in that area and roughly the numbers of small, medium, and large, among those trees. The amount of brood lac required to inoculate a tree may be defined as "That weight of brood lac sufficient to cover all the shoots available for infection fairly closely with larvae, leaving no shoots uncovered and no larvae with no suitable place on which to settle." The amount can really only be learnt by practical experience, however a rough idea can be formed from the following Table in which amounts found sufficient for various hosts are tabulated as a guide. The correct amount of brood, is important as any shoots left un-infected are so much wasted space, and excess of larvae is not only a waste of brood lac, but also causes mortality among the larvæ due to over-crowding on the young twigs, and by forcing the larvæ to settle on the thick mother shoots owing to want of space, where they cannot survive:— **Correct amount of brood for inoculation.** **Over infection.**

TABLE XIII

Weight of brood necessary for infection.

Host.	Large.	Medium.	Small.
Palas.	2-3 seers.	½-1 seer.	3-4 chitts.
Ber.	3-6 seers.	1-2 seers.	3-5 ,,
Khair.	3-4 seers.	1-2 seers.	3-4 ,,
Kusum.	10-20 ,,	5-10 ,,	1-2 seers.
Ficus sp.	4-6 ,,	1-2 ,,	½-1 ,,

Swarming should begin from the brood within one to two days of the date of tying it to the lac hosts. (cf Chapter VIII). This date should be observed, brood should be removed from the tree no later than three weeks from the date that *swarming began,* and may be removed with advantage two weeks or even earlier from the date swarming began, if the trees are well covered with larvæ. The importance of this in the control of insect enemies of lac is explained in Chapter XIX. **Removal of brood.**

During the inoculation period the trees should be examined periodically, and as soon as the available branches are found to be covered with a close carpet of larvae the brood should be removed. It must be remembered that

the larvae will not settle at the extremities of the new shoots, as this region is too immature, and the last few inches of the shoots will therefore, not be colonised: nor will the larvae settle on the basal part of the shoots if the shoots are long and the basal part is thickened.

Transference of brood to fresh hosts.

Brood that has been removed during the first 2 weeks from the date of swarming can be transferred to other trees for infection purposes or tied to infected trees which have not received sufficient brood and are, therefore, under-infected. Of course transference can be done in the same way among individual branches of the same tree.

Infection where labour is scarce.

In certain cases where very large areas have to be infected and it is difficult to obtain labour or where infection must be done in a hurry, rather more haphazard methods of inoculation are used. These generally consist mainly of, loosely interlacing brood sticks between the new shoots for infection with or without tying, the more general use of bundles of brood sticks thereby saving separate inoculation of the smaller branches, and the tying of brood sticks to the branches in the middle of the stick only, by means of a piece of string or grass.

Infection during the Monsoon.

When carrying out this process in the Monsoon infection season, that is June—July, the brood should not be tied to the trees during rain particularly if the larvæ have started to swarm as many will be washed away before they have time to settle. The mother lac cells are alive at the time of swarming, not dead as was previously believed and can to some extent control the swarm, delaying it, if climatic conditions are adverse; this means that if the brood has been tied to the tree with no larvæ crawling on it, the lowering of temperature accompanying rain will to some extent cause the mother cells to delay the swarm. The optimum time for infection in this season is early, on any sunny morning when there is a fair prospect of 4-6 hours of warm, rain free weather, which will give the larvæ a chance to settle.

Measures used for sale of brood.

Brood lac is sold according to different measures as prevailing in the district concerned. The commonest method in Bihar is by the Chittack or Seer for the villager and by the Maund for more wealthy cultivators. Another method common in this Province is the Hath; this is the number of brood lac sticks that can be tied round with a string 1′—6″ in length; a two Hath bundle is that amount of brood that can be tied with a string 3′ long and so on; roughly a Hath equals 2 seers.

The brood lac which is removed from the tree is of course phunki as it contains only the dead bodies of the female insects. The encrustation should be scraped at once from the twigs, and can then be sold for manufacture into shellac.

Natural Infection.

The instructions so far given apply to Artificial infection, there is however another method which is known as Natural infection. Instead of removing

PLATE VI.

Butea frondosa (Palas).

Showing longitudinal infection, Arrows point to brood sticks. Note leaf stalk on brood sticks.

Kundri, Palamau District, Bihar. October, 1930.

the mature lac from the tree when it is mature and about to swarm, all or part of it is allowed to remain on the tree uncut to swarm *in situ*.

The practice of natural infection is *not* to be recommended in spite of its simplicity except under special circumstances. Trees thus cultivated do not receive a periodical rest, and uniform infection is never possible and regular crops cannot be obtained. The crop when cut is less valuable as brood, as it contains a percentage of dead lac from the previous crop ; it is also even slightly less valuable as stick lac as it contains fresh lac mixed with some old lac from the previous crop. The main objection to natural infection is, however, that it tends to favour the multiplication of predator and parasite enemies of the lac insect. (cf. Chapter XIX).

There are, however, circumstances under which natural infection must be allowed, these are discussed and explained at length in the chapters relating to the individual treatment of lac host trees.

CHAPTER VIII.

FORECAST OF SWARMING DATE, REAPING THE LAC CROP, AND SUBSEQUENT TREATMENT OF THE LAC.

Lac is cropped from the tree both for use as brood and for manufacture into shellac. Where the crop or part of it is required for brood the lac must not be cut until swarming is about to occur, where the crop is being cut for sale for manufacture it may be cut some little time before swarming is actually due.

It must be remembered that cropping and pruning are really the same process as has been explained in Chapter VI and the instructions given therein should be carefully followed.

Cropping times.

The times at which lac is cut are the following:—

1. *June—July.*

   (*a*) The **Jethwi** crop is cut for sale or for use as brood.

   (*b*) The **Baisakhi** crop is cut. (In the case of the Baisakhi crop it is very generally partially cut in April—May, leaving a certain amount of lac on the tree to act as brood, this may be allowed to swarm *in situ,* (natural infection) or be cut for brood.

2. *October—November.*

   (*a*) The **Katki** crop is cut for sale or brood.

3. *January—February.*

   (*a*) The **Aghani** crop is cut for brood or sale, where the Aghani crop is being cut for sale for manufacture only, cutting is often started in December—January or earlier.

4. *April—May.*

   (*a*) The **Baisakhi** crop is usually partially cut in April—May for sale ari for manufacture, a part being left on the tree to swarm naturally in July or to be cut as brood, or for sale.

Where the crop or part of it is not required for brood, lac should be scraped from the twigs as soon as possible.

Blocking.

There are however certain pitfalls that must be avoided. The lac contains as well as the encrustation, the bodies of the female insects and of

PLATE VII.
Crop Reaping *Zizyphus*
Jujuba (Ber). Namkum, Bihar.

some of the enemy insects which affect lac (*cf.* Chapter XIX). If this lac is put into bags or left in a heap, warmth and pressure set up fermentation and will cause the lac to stick together into a number of lumps or blocks which may become almost unbreakable. This is known as 'blocking' and lac in this condition is known as blocked or blocky lac. These hard blocks make manufacture extremely difficult if not impossible, the lac also looses some of its chemical and physical properties and hence deterioates in value. Blocking occurs most easily when lac is ari but may occur in phunki lac also. Special precautions must be taken with the former ; care must also be taken that phunki lac does not block. Should lac be found to have blocked, the blocks should be broken up at once, if left for any length of time, nothing will break them.

Prevention of Blocking.

To prevent blocking lac should be spread out on a clean pucca floor in as cool a place as possible, and out of the sun. The lac may be spread in a layer 4"—6" deep, and should when fresh cut, particularly if ari, be raked over once a day at any rate until it has dried to some extent. Later, raking should be done periodically to allow æration. When dry the lac should be sold at once for manufacture. Chemical fumes such as ammonia and acid fumes are extremely harmful to lac.

Evil effects of Storage.

Lac should be sold for manufacture as soon as possible after cutting, lac deteriorates in store and it is a bad practice to store it for any length of time, particularly in hot arid districts. This is further discussed in Chapter XIX. So much for lac that is not required for use as brood.

Swarming, and disadvantages of premature cutting.

The female lac cells as previously stated are alive at the time of swarming and can to some extent control the swarm, delaying it if climatic conditions are such that the young larvæ will be adversely affected. Examples of such adverse conditions are heavy rain and intense cold. Premature cutting of lac to be used as brood is extremely harmful. The reason being that the living female insects are cut off from their food supply the host tree. This necessarily weakens the female insect and causes her to loose to a less or greater extent the power to control swarming. It also affects adversely the young larvæ themselves as they, through the mother insect, are cut off from their food supply. From lac cut several weeks before swarming either no larvæ will emerge, or a few devitalised larvæ only will swarm out. Premature cutting is therefore extremely harmful to the cultivator. Lac for use as brood should on no account be cut earlier than 8-10 days before swarming is due, and later cutting is preferable.

Disadvantages of late cutting.

Late cutting is also harmful, if the lact is not cut until swarming has started, if the area is at all large and the weather favourable to swarming, much of the swarm may be lost before the lac can be cut, selected, and tied to the new host trees.

It is therefore of great importance to know how to tell when lac is due to swarm. In any given district swarming occurs at very approximately the same time each year, but the actual date of swarming may vary as much as 3-4 weeks from one year to another.

Variation in Swarming date from year to year.

The following Table shows the variation in swarming times of Palas lac in the Kundri plantation, Daltonganj, Palamau Division from 1920 until the present time.

TABLE XIV

Dates on which Palas lac began to swarm at Kundri Plantation, Daltonganj, Palamau Division.

	Baisakhi	Katki
1920		October 25th
1921	July 20th	October 21st
1922	July 10th	October 10th
1923	July 22nd	October 24th
1924	July 23rd	October 23rd
1925	July 4th	October 6th
1926	July 26th	October 31st
1927	July 16th	October 17th
1928	July 9th	October 10th
1929	July 14th	October 12th
1930	July 15th	October 17th
1931	July 20th	October 7th
1932	July 17th	November 1st
1933	July 16th	October 10th
1934	July 17th	October 21st
1935	July 22nd	October 22nd
1936	July 4th	October 6th.
1937	July 17th	October 18th

Factors governing Swarming.

Oviposition incubation and emergence (swarming) are governed by temperature and are unaffected by humidity within the range 58—100%. The actual fertility is highest in July—August, intermediate in October—November and lowest in January—February. Actual fertility depends upon the potential fertility, which is apparently directly dependant upon the temperature during the maturation of the ovaries, and upon the percentage of ovules which are undelivered which is inversely dependant on temperature at the time of oviposition.

Egg laying practically ceases below a temperature of 17°C (63°F) in Summer and below 15°C (59°F) in Winter. Larvæ are inactive below a temperature of 20°—22°C (68°—72°F). Larvæ which hatch and remain in the incubating chamber of the female cell die after 4—5 days.

Inducing Swarming that has been delayed.

If the atmospheric temperature during the oviposition period is unfavourable to oviposition and emergence *i.e.* below 18°—20° (65°—68°F), emergence of larvæ from brood lac will be naturally delayed, a situation which may arise during the February—March period. Swarming can be induced as follows: —

If the day temperature rises above 20°C, (68°F) tying the brood to the hosts to be infected, in the sun light will cause emergence to occur.

Maintaining the brood in a warm room at a temperature of 24°—28°C (75°—82°F) will cause emergence to occur; if the brood is then taken and tied to the host plant swarming will cease, however, unless the day temperature exceeds 20°C (68°F) and only those larvæ which have already emerged will move on to the host plant; continuous emergence will not occur. Emergence can be re-started by returning the brood to the increased temperature once again.

Subjecting the brood to a temperature of 2°—13° C (36°—55° F) for a period of 1-4 days will cause continuous swarming to occur 2-3 days after return of the brood to atmospheric conditions.

Sending brood lac by train.

Safe carriage of brood lac nearing the oviposition period over long distances, journeys of 9-10 days, is therefore a possibility if it is transported at an artificially reduced temperature of 15°—17°C (59°—63°F), the fertility and vitality being not considerably harmed: thereby avoiding premature cutting which is devitalising, and avoiding the danger, accompanying late cutting, of emergence occurring during transit: oviposition preferably should not have begun before despatch at reduced temperature. (cf. page 59 also.)

The yield of lac and percentage of females in the progeny is not adversely affected as result of subjection of the mother to lowered temperatures.

Length of Swarming period.

The average egg laying period for an individual female cell at all seasons is about 7 days and the maximum 14 days, the greatest number of eggs is laid between the 2nd and 6th day of the egg laying period.

The average swarming period of a single female cell of the Baisakhi crop (in July) is 6 days and the maximum 11 days. In the Katki crop (in October) 7 days is the average and 16 days the maximum swarming period. Aghani periods are similar to the Katki. The greatest number of larvae to swarm per day from a given female cell, does so between the 1st and 5th days of the swarming period.

All cells do not swarm simultaneously, in 2 weeks the greater part of the emergence has usually occured from all cells and after 3 weeks swarming has generally ceased. This is further referred to in the section on control of insect enemies of lac.

Swarming is usually at its height from any given brood as a whole at about the 3rd or 4th day of the swarming period. Brood from which swarming has begun *but is only in the early stages,* need not be rejected on the count that swarming has begun.

Sex of progeny.

It has been shown at Namkum that the statement that is sometimes made that the first batch of larvae to swarm is mainly female and those that appear later are chiefly males is incorrect .Emergence is of a mixed character and there is no relationship between sequence of emergence and sex ratio.

The Baisakhi crop grown under arid conditions produces females (in July) whose progeny in the majority of cases is predominantly female, in some, cent per cent female and in a few intermediate.

The Katki crop, grown under humid conditions, produces a major number of females (in October) whose progeny is again predominantly female, a few whose progeny is predominantly male and some whose progeny is intermediate. This is further discussed in Chapter XXII.

Direct observation of swarming.

Where cultivation is done on a small scale only, it is frequently the practice to leave the lac on the tree uncut until the first crawling larvae are seen. It is then cut quickly and tied to the new hosts. This practice may be possible where cultivation is on a small scale, and where labour is plentiful, but it may result in a very great loss of larvae before the brood can be got on to the new trees if there are a large number of trees infected. Swarming it should be remembered is at its maximum during the first week of the swarming period.

Even when this practice is followed there are certain points against which the cultivator should be on his guard. In June-July and in October-November the appearance of few lac larvae means that swarming is imminent and that general swarming will occur in the course of a few days and indicates that the lac may be cut at once. In January-February however the appearance of a few scattered larvae may not mean that swarming is imminent and at that season if this practice is being followed the lac should not be cut until a few larvae are seen on the majority of the infected branches on the lac infected trees: faith should not be pinned on the appearance of a few larvae on occasional branches on a few trees.

Forecast of Swarming Date.

In most lac growing districts the raiyat cultivator is able to forecast the date on which lac will swarm with fair accuracy simply by the appearance of the encrustation. Misra (1928) describes a method of forecasting emergence by means of microscopic examination of the developing ovules in the lac cell. this however is quite unsuited to the average cultivator and moreover although accurate in June-July and October-November is by no means accurate in January-February.

The following simple phenomena may be used to judge approximately when crop maturity and swarming will occur. **Simple indications of Swarming.**

1. *Granular appearance of the body contents of the female cells.*

If a cell be crushed between the fingers, the body contents will appear granular about 3-4 weeks before swarming in the Baisakhi, Jethwi and Katki crops: 5-6 weeks before in the Aghani. From the time this is first observed the granular appearance becomes more and more prominent up to the time of swarming.

2. *Appearance of cracks in the encrustation.*

Cracks make their appearance in the encrustation about 2-3 weeks before swarming is due in the Baisakhi, Jethwi and Katki crops, in the Aghani 4-5 weeks.

3. *General appearance of the encrustation in all lac crops.—*

The encrustation has a drier appearance about 2 weeks before swarming is due, and can be peeled off from the host twig or branch with greater ease.

The white filaments do not necessarily disappear as swarming becomes imminent as is believed in some districts, nor has swarming any connection with the phases of the moon. It may also be recorded here that the larvae once having left the mother cell, never return to it, the belief that larvae return to the mother test at night or under unfavourable conditions is incorrect. Larvae are capable of crawling considerable distances and may crawl for 2-3 days, if however they have not settled down by this time they die. **Superstitions as regards Swarming.**

Accurate forecast of emergence may be made by examination of the orange yellow area of the female cell. On the dorsal area of every female cell, there are three pores through which waxy white filaments project. Two of these three holes are very small and hardly appear as holes to the naked eye, but waxy threads can be seen arising from them. These are the brachical pores or breathing pores. The third pore is much larger in size, prominent and is situated at a slightly higher level than the brachial pores. A thick bunch of white waxy filaments covering the brownish anal ring setae general projects from it. This is the anal tubercular pore, and it is in the neighbourhood of this pore that the orange yellow spot which may be used to forecast swarming, appears. (cf. also Chapter I.) **Accurate forecast of swarming by Yellow Spot Method.**

The spot appears at the posterior end of the cell and is to be seen behind and below the anal tubercular opening. Lac cells are normally dark red brown in colour, because although lac is a translucent substance of a yellow orange colour, the insect body being in contact with the cell wall, light is unable to pass. Shortly before swarming muscular contraction occurs within the insect body, drawing it away from the cell wall in the posterior region of the cell. The cell wall, away from which the insect body has been withdrawn

by this muscular contraction, immediately allows light to pass and appears orange yellow in colour because it is now translucent. This translucent area corresponds to the orange yellow spot. As swarming becomes more imminent this body contraction continues the orange yellow area increases in size. The relative size and position of this area in respect of the three openings referred to above, is the index by which forecast of emergence is made.

The cavity formed by this contraction acts as an incubating chamber within the lac cell, into which the eggs are laid via the genital aperture. In this chamber the eggs hatch and from it the larvae emerge to the outside via the anal tubercular pore, from which the tubercle is withdrawn during the process of contraction.

In order to ascertain that examination is being made of a female which is healthy and capable of laying eggs, the white filaments or bunch of bristles projecting from the anal tubercular pore should be touched with a needle or thorn, if the insect is healthy the bunch of bristles will be partly withdrawn into the cell and usually a small drop of honey dew will appear at their tip. If repeated touching produces no effect, the cell should be neglected and another one chosen. At first at any rate forecast should be carried out on isolated cells or semi-continuous encrustation. Such cells can usually be found readily enough in all lacs, even Kusum, if searched for.

Having decided upon suitable cells the portion of the lac test just below the anal tubercular opening i.e., the largest opening, should be freed from the coating of dust or other foreign matter by gently rubbing with the finger and the deep yellow area looked for, facing the cell in such position that only the white wax bunch protruding from the largest hole is seen and not those from the other two sub-equal smaller holes.

The thick and comparatively compact growth of resin in Kusum lac cells gives a slightly different shape to the cells than that of cells on other host plants. The deep yellow spot in the Kusum cell is situated a little lower down on the test than in cells on other host plants.

Parasitised and unhealthy cells some times show orange yellow colouration. In order therefore to make sure that the cells examined were healthy, they should be crushed or broken after examination. A healthy cell at this time should when crushed between the fingers, colour them with a fair amount of red dye which should contain large numbers of small granules. If the cell on crushing is found to contain one or more white grubs, or pale yellow brown or black pupae, it is parasitised. If it shows a shortage of lac dye absence of granular contents, or should the contents be dry and dark red coloured, the cell is unhealthy or dead. In either case a fresh cell should be chosen.

In forecasting, by this method, a small hand lens magnifying from 4 to 10 times will be found very helpful. Such a lens may be obtained for a few

PLATE VIII

Butea frondosa (Palas) from which the crop has been cut. Note infected branches at foot of tree. Tree has been much too heavily cut.

Kundri, Palamau District, Bihar, October, 1930.

rupees only, from any instrument dealer such as Messrs. Adair Dutt & Co. 5, Dalhousie Square East, Calcutta, or Messrs. Scientific Instrument Co. 11, Esplanade East, Calcutta.

In fairly large areas the Baisakhi Katki and Jethwi crops should be cut when the stage shown in coloured Plate I, fig. 9 is reached. The Aghani crop should be cut at the stage shown in fig. 10 if the weather is favourable.

This method of forecast is explained in detail, in a paper entitled 'A simple method for the forecast of emergence of Lac Larvae' by P.S. Negi, it has been translated also into Hindi, Bengali and Oriya. Obtainable from the Director Indian Lac Research Institute.

These signs should be carefully observed, and the crop should be cut 3-5 days before swarming is due, according to the number of trees infected, the object is to cut just sufficiently long before swarming to allow time for cropping, selecting and tying of brood to the new trees before swarming starts.

Brood lac for despatch over long distances.

Brood lac which is to be sent long distances should be cut just long enough before swarming to allow it time to reach its destination and be tied to the trees before swarming occurs. To get satisfactory results however 8-10 days is the earliest that it should be cut and this even is somewhat premature.

It has however been possible to despatch brood lac from Namkum over journeys as long as a week by packing it loosely criss-cross in light bamboo baskets with a bamboo lid stitched on, and otherwise uncovered, and sending it per passenger express train. Brood treated in this way arrived in a satisfactory condition even after a weeks journey, after shorter journeys it arrived in excellent condition. However it may be well to reiterate, brood for normal purposes should be cut as soon before swarming as possible, and if possible never earlier than 5 days to a week before, for optimum results.

April-May Crop Cutting.

In the introductory chapter, the crop cutting period of April-May was mentioned, the significance of this process will now be explained further. In both the short crop, the Katki (4 months) and the long crop, the Baisakhi (8 months), approximately the same amount of resin is built up by the lac insects, that is to say the same number of insects will make roughly the same amount of lac in either crop. In the Katki crop, lac secretion continues practically until the time of swarming, in the Baisakhi season, resin secretion decreases very considerably about 1 month before swarming, and after this time very little further resin is built up, therefore in April-May the greater part of the lac secretion is over. In many districts as for example Palamau, very high temperatures occur in April-May-June and are extremely trying to the lac and also to the host tree and the problem arises how to get sufficient lac to survive these months and live to give rise to brood lac in July. This is overcome as follows, part, generally 2/3rds, of the crop is cut from the tree

in April-May and is sold as stick lac, it is of course ari. When this cutting is being done any dead, dying, or pest affected lac is cut, the most healthy lac only being left. The part that is left is also chosen so that it shall be shaded as far as possible by branches and leaves of the tree, usually near the centre of the tree towards the top. This cutting relieves the tree to a certain extent of the drain being made by the lac insects feeding upon it, in many cases trees that would fail to support a full crop are capable of supporting a 1/3rd crop satisfactorily. Frequently all the lac is cut from the majority of trees, a small percentage only being left as above with 1/3rd uncut to yield brood lac in July for natural or artificial infection. This minimises the chances of theft during May and June and saves the cost of chowkidars to prevent theft. Another advantage in the case of Palas is that this partial cutting acts as a pruning and the new shoots to which the tree gives rise are ready to receive the larvae, from the 1/3rd of the crop left to give rise to brood lac, in July. This is further explained in the chapter on the host Palas. There is no or practically no loss from this early cutting as by this time lac secretion has practically finished as has already been explained. Naturally a tree bearing only dead lac at this time is completely cropped.

This partial cutting is generally done in may.

This immature cutting can be done only in the Baisakhi crop and its application to Palas and Ber will be explained in the chapters on these hosts. In the Katki Aghani and Jethwi crops lac secretion continues practically until the time swarming commences. (See also Chapter I).

Yields.

The yield that may be expected varies very considerably and depends on a large number of factors. Among these are climatic conditions temperature and rainfall during the crop, the prevalence of insect enemies of lac and the correct pruning and use of the host.

As a rough guide the following method may be utilised.

In general a brood-yield ratio of 1 to $2\frac{1}{2}$ or 1 to 3 may be expected, i.e., the yield that will be obtained is approximately $2\frac{1}{2}$ to 3 times the amount of brood used, from 10 seers of brood a yield of 25-30 seers may be expected from an average good crop.

An inspection should be made, if the crop is found to be below average a yield of $1\frac{1}{2}$ to 2 times the amount of brood used may be expected. In a really good crop brood-yield ratios of as much as 1-5, 1-7 and even more may be obtained. The average ratio is however as has been stated about 1-$2\frac{1}{2}$ or 1-3.

In the yield, good healthy lac fit for use as brood is counted only, very poor sparsely covered sticks are omitted.

The most satisfactory comparison is of course that of scraped lac from the brood used, with scraped lac from the yield obtained, to which it will be found that the above figures also apply fairly closely.

A figure of importance to the cultivator is the weight of scraped lac that he may expect from a given weight of lac on the stick. **Yield of scraped lac from lac on the stick.**

In the case of Rangeeni, i.e., non-Kusmi lac, the yield of scraped lac that may be obtained from 1 maund of lac on the stick is on the average 33%, which is approximately 1/3rd, which amounts to just over 13 seers scraped lac per maund of lac on the stick. Katki lac gave a slightly higher yield than Baisakhi, and Palas a slightly higher yield than Ber.

In the case of Kusmi lac i.e. lac grown on Kusum or on other hosts using Kusum brood, the yield of scraped lac that may be expected from 1 maund of lac on the stick is on the average 50% or one half, amounting to 20 seers scraped lac per maund of lac on the stick. Yields from the Aghani crop were slightly higher than those from the Jethwi. Yields from pure Kusum were slightly higher than those from the strain Kusum x Khair. These weighments were made in all cases about 3 weeks after cutting the crop.

Stick lac, (lac scraped from the stick) looses weight during storage, this loss depends on several factors. This loss may be considered to take place in two definite stages:— **Loss of weight by stick lac on storage.**

(*a*) The initial drying which occurs during the first few weeks after the crop is cut and which may be very large and may vary between wide limits upto as much as 30% or more.

(*b*) The subsequent loss of weight on lengthy storage which is small relative to (*a*).

The factors influencing the extent of this loss are varied: the initial dryage is influenced by the following factors.

1. Whether the crop was cut ari or phunki. In the former case the loss will be much higher than in the latter, in the case of ari lac, if mature there is a loss due to the weight of the larvae which swarm out, and whether mature or immature there will be the loss due to the dryage of the bodies of the female insects.

2. The amount of organic, woody matter mixed with the lac, which will loose weight due to dryage.

3. The atmospheric conditions prior to and during the time of cutting, on which the moisture content of the lac depends.

4. Loss of weight due to the emergence of parasite enemies of the lac, this loss is however not likely to be large.

The factors which influence the subsequent loss are the following.

1. Loss due to insects.

(*a*) Loss of weight due to the feeding and ultimate emergence of the lac predators *E. amabilis,* and *H. pulverea.* The extent of loss will depend on how badly the crop was affected by these predator insects. Such loss will occur during the first two months of storage except in the Katki crop where it continues upto the sixth month after cutting.

(*b*) Loss due to feeding by stored product pests of which the most serious are *Pyroderces falcatella, Ephestia sp.* and *Tribolium castaneum.*

This type of loss due to insects may be as high as 10%.

2. Polymerisation, depending on the temperature during storage and the packing of the lac. This may amount to 1%—2% of the loss if stored for a year under bad conditions.

3. The moisture content at the time of weighing, which depends on the atmospheric conditions, and may vary about 1%—2%.

The original initial loss is unavoidable. The subsequent loss is unnecessary and would not occur if the practice of storing lac was abandoned. All lac should be sold for manufacture as soon as possible after cutting, and should be converted into seedlac without much loss of time. Lac deteriorates during storage and storage also allows the insect enemies in the lac to emerge and find their way to the lac on the tree to lay their eggs and infect the young crop with pest. Conversion of stick lac into seedlac is a satisfactory control against the stored product pests, *P. falcatella, Ephestia sp.* and *T. castaneum,* which do not attack seedlac. These insects are not resin feeders, they are for the main part scavengers feeding on dead insect bodies and organic matter generally, they are damaging in that they bite through the cell walls to feed on the dead bodies of the lac insects.

Very few figures of dryage on large quantities of lac are available. The following record is interesting.

800 maunds of Palas ari Baisakhi lac collected June 3rd—9th stored on a stone paved floor, fair aeration, originally stored 6" deep and later 9". The dryage in August was 18·9%, in September 20·6% and December 22·7%, *i.e.* a loss of over 1/5th in six months.

Loss due to dryage at Kundri for Palas lac, cut in May, over 3 years averaged 17% to 25% or 7 to 10 seers in the maund.

The loss due to dryage from ari lac weighed *immediately* after cutting at Namkum whether Baisakhi Katki Aghani or Jethwi was in the region of 33%, that is to say, $\frac{1}{3}$rd or approximately 13 seers in the maund.

Data to hand suggests an allowance of 5—10 seers in the maund for dryage as a practical working figure for all lacs after cutting, for use in States, zamindaries or large plantations.

CHAPTER IX.

MANUFACTURE OF SHELLAC.

The stick lac produced by the cultivator eventually reaches the manufacturer either ari or phunki. In the Factory it is converted from the raw material, lac, into the final form in which it generally reaches the world's markets, known as Shellac. During the process a number of bye-products are formed which also have their uses.

The short account of the process of manufacture which follows, is largely taken from the account given by Dr. Aldis, late Physico-Chemist at Namkum, in "Lac and the Indian Lac Research Institute" by Norris, Glover and Aldis.

Indigenous process.

The manual country process of shellac manufacture is the most widely used and is responsible for about 75% of the world's output. The process can be conveniently separated into three steps, *i.e.*, the production of 'crushed lac', 'seedlac' and 'shellac'.

Crushing.

The method adopted for the preparation of crushed lac depends on the type of raw material. There are two main types (*a*) Kusum lac with thick encrustation still firmly attached to short lengths of stick and (*b*) Baisakhi and Katki lac which has a thinner encrustation and can readily be removed from the accompanying stick by scraping. In the case of the former material, the lac is crushed in a roller corn crusher (power driven in some of the larger factories) with the space between the rollers so adusted that the lac is broken from the sticks which can be separated readily by subsequent sifting. In the case of Baisakhi type lac the encrustation is scraped off and the sticks removed by hand by picking and winnowing before going to the crushing machine.

Washing.

The crushed lac is now ready for the washing process. The apparatus consists of a row of tea-cup shaped stone or cement pots or *nands* about $2\frac{1}{2}$ feet in height and diameter; the inside having a special roughened surface. About 40 lbs. of crushed lac are placed in a pot, covered with water and washed by the Ghasander. He stands in the nand and rubs the lac with his feet against the rough sides of the pot and so crushes the lac cells and washes out the dye. The dye is crimson coloured, and consists of the colouring matter of the bodies of the lac insects. The crimson coloured water is generally allowed to run away. Sometimes it is let into large vats, however, in which the dye settles and is collected. The dye originally an important product, has now only a limited market, due to competition from synthetic products. After about half an hour of this operation the water is allowed to settle and the surface scum, consisting of sticks, fibrous and animal matter, is removed. The water is then scooped out and roughly filtered through cloth to remove suspended lac. The process is repeated three or four times until most of the dye has been removed. After the last washing the 'seedlac' as the material is now

Lac Dye.

Seed lac. called, is spread out to dry on a cement floor. In recent years an increasing amount of seedlac has been exported from India as such, without further treatment. This material is chiefly consumed by American bleached lac manufacturers. For export the 'seedlac' is graded according to colour and solubility in alcohol. Baisakhi type lac cannot be economically washed to give a 'seedlac' with low insolubles. Accordingly this seedlac is always blended with a proportion of Kusum type seedlac, lac from Burma and Siam being convenient and cheap for this purpose. Unfortunately the 'bleachability' of Burma and Siam lac is not good and seedlac consumers are beginning to realise that low "insolubles" content is not necessarily a criterion of good 'seedlac' for bleaching purposes.

Melting. If the 'seedlac' is to be converted into shellac it is subjected to a melting process. A mixture is prepared from various seedlacs blended according to colour and fusibility. A very old seedlac with low fusibility requires addition of fresh seedlac to ensure a good yield. In certain cases rosin may be added, in quantities up to 12%, nominally for the same purpose. To meet trade requirements of colour a suspension of yellow arsenic sulphide is sometimes mixed in and dried. The higher qualities of lac are free from rosin and orpiment, the use of orpiment is inadvisable*. The blended lac is now poured into a cloth bag about 30 ft. long and 2 inches in diameter. The quality of the resulting product is governed partly by the quality of the cloth used. Close woven drill is used by some manufacturers, while others prefer a double bag of cheaper cloth. The source of heat consists of a Dutch oven-shaped fire-place or *bhatta* about 2 feet long by 1½ feet high and 1 foot in depth containing a well glowing charcoal fire. At one end of the fire sits the melter or *Karigar* holding one end of the long bag. The other end is rotated by a small boy (*phirwaya*) using a simple windlass. The heat of the fire melts the lac which is squeezed through the cloth by the Karigar applying resistance to the twisting. The lac filtering through the bag is worked up with a large iron spatula to ensure thorough mixing of the lac and the wax which tends to separate. Over-heating is prevented by an occasional sprinkling of water. When sufficient lac has collected on the outside of the bag and has been sufficiently worked the molten mass is rapidly transferred to the glazed porcelain surface of a horizontal hot water cylinder 2½ feet long and 10 inches in

Spreading. diameter. An assistant or *Bhilwaya* spreads the mass evenly over the cylinder by means of a palm frond. The sheet is then removed and after warming

Stretching. before the fire, is stretched by means of the Bhilwaya's hands, feet and teeth. When cool the thick edges and any observed specks of dirt are removed, the sheets are broken up and the resulting product is the shellac of commerce.

Button lac. In certain cases the stretching process is dispensed with and so-called 'Button lac' is prepared by scooping up small quantities of the molten lac and dropping them on to a zinc sheet instead of transferring them to the hot water bottle. The resulting buttons of lac, about three inches in diameter and ¼ inch thick, are stamped with the manufacturers mark just before they set hard on cooling.

* It is usually used to disguise bad colour.

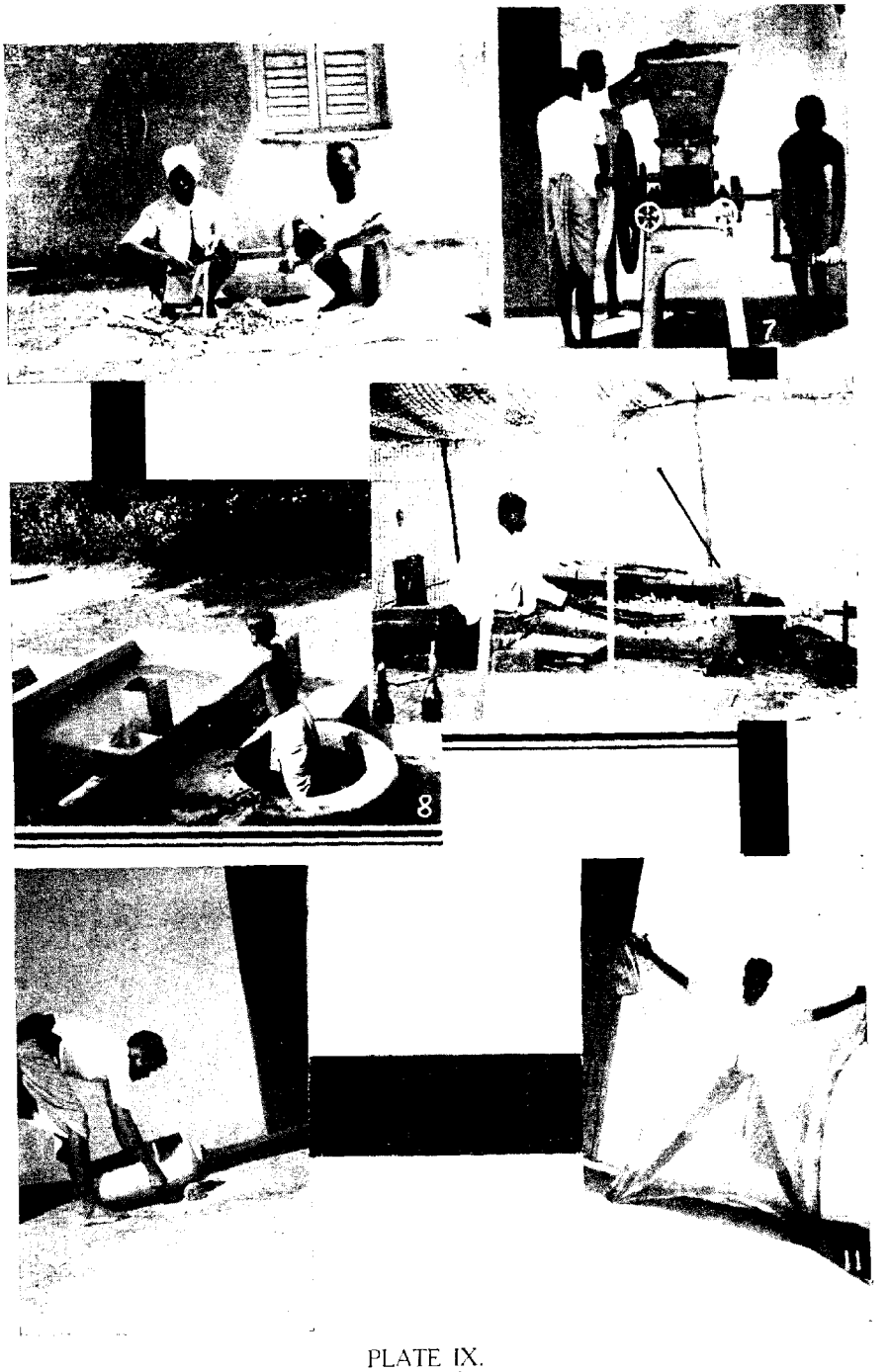


PLATE IX.

Shellac manufacture.

6. Scraping Kusum × Khair lac. Lac Research Institute, Namkum.
7. Grinding Lac. Experimental Lac Factory, Namkum.
8. Cooly Washing Lac. Experimental Lac Factory, Namkum.
9. Shellac Manufacture. Ranchi Mela, 1935.
10. Spreading molten Shellac on porcelain cylinder. Experimental Lac Factory, Namkum.
11. Stretching Shellac. Experimental Lac Factory, Namkum.

The country process is remarkable in that the purification is carried out using the minimum amount of heating. Thus the good properties of shellac, so readily destroyed by heat, are retained. The process is not economically inefficient except for the large amounts of bye-products which sell at unremunerative prices. The main bye-products are:— **Bye-products.**

(a) *Molamma.*—This is the finely divided, dustlike, material separated from the seedlac. It may contain up to 70% shellac. **Molamma.**

(b) *Kiri.*—This is a bye-product of the melting process. When the pure shellac filters through the bag it leaves the dirt and refuse behind. When sufficient of this has collected the bag is slit and the accumulation, usually about 3 lbs., is scooped out and pressed into a cake about $\frac{1}{2}$ inch thick. This contains about 50% shellac. **Kiri.**

(c) *Passewa.*—After the melting process the used bags have the appearance of twisted rope and contain about 5% shellac which could not be squeezed out. This shellac is removed by boiling the bags in dilue soda solution. The lac is loosened and floats to the surface where it is collected and is pressed into cakes called passewa. This material contains about 90% shellac. Incidentally this process serves to wash the bags which, after drying and repairing by the tailor can be used again for manufacturing shellac. **Passewa.**

Other less important bye-products are *Patti* and *Banch*.

The bulk of the shellac manufactured by the country process is of quality known as TN, a term dating back to the earliest days of shellac manufacture. A somewhat superior quality is known as Standard I and still purer shellacs are known as 'Fines' and 'Superfines'. Most manufacturers have their own 'mark' for the particular grade of 'Fine' and 'Superfine' shellac their factory produces. **Grades of Shellac.**

About 25% of the worlds output of shellac is made by mechanical processes. These are used in one factory in Calcutta and several on the continent of Europe. Many methods are employed including solvent extraction processes using alcohol, and steam heating and pressing processes. The details of the procedure used are guarded as trade secrets; the few patents which have been taken out giving very little fundamental information. A large range of qualities are produced varying from a very dark 'garnet lac' with large additions of rosin, to an extremely pale coloured shellac which is prepared by decolourising an alcoholic solution with animal charcoal and evaporating off the alcohol. This product is superior in colour to any shellac made by the country process. Solvent extraction methods are also advantageous in that wax-free shellac can readily be prepared by this means. Marketing of wax-free shellac and its use in conjunction with cellulose lacquers may well develop into an industry of considerable importance. **Mechanical Process of Manufacture.**

For a short concise account of the Chemistry of Shellac, Sen, (1937) may be consulted.

CHAPTER X.

THE USE OF SCHLEICHERA TRIJUGA (KUSUM) AS A LAC HOST.

General.

Kusum is a slow growing tree, and one that grows to a very large size. It produces the best quality lac of any host. Kusum is seldom found growing gregariously, although definite areas occur which contain Kusum trees in considerable quantities. It is a host used to a very large extent by the raiyat cultivator, and is probably more abused by him than any other lac host species.

Kusum is a forest tree of some considerable value, its wood is hard and is used for many purposes, the fruits are edible, and the seed yields an oil (macassar) of some value. *S. trijuga* is although deciduous practically an ever green as the flush of new leaves takes place often before leaf fall is complete. It not only yields the highest quality of lac, but on account of its size when mature the lac crops collected from it are much larger than those collected from any other host. See also Chapter V.

Crops for which Kusum can be used.

As has been said in Chapter I, Kusum is an Aghani and Jethwi host, July infection giving rise to a crop in February and February infection to a crop in July. Kusum can be utilised for either crop, its great value in the Jethwi crop being that the new flush of leaves occurs at the onset of the hot weather (March) and that the young crop is shaded and protected by the leaves during the hot arid months of April, May and early June, and is enabled to survive the heat to give brood in July.

Pruning.

In the chapter on pruning it has been explained that Kusum is *not* tolerant of heavy pruning, from which it takes a considerable time to recover, the villager's abuse of this valuable host is very largely due to disregard of this fact. The general method of Kusum pruning is to cut through large branches and trunks with axes, partly to save time and trouble. The result of this treatment is that the tree usually takes from 2—3 years to recover and is generally dwarfed in frame. To get the best results from Kusum it should be pruned lightly, according to the methods laid down in Chapter VI. Pruning should only be done in July or in February.

Raiyat's harmful method of using Kusum.

The raiyat method of using Kusum demonstrates practically every fault in cultivation that it is possible to make:—

The raiyat either cannot afford, or is not prepared to risk, the amount of brood necessary to infect fully a well grown Kusum tree. Therefore optimum pruning to obtain the maximum number of infectable shoots is not of great importance to him. The future of the tree is not of course considered, and the ease and simplicity of cutting though large limbs outweighs any consideration of diminution in the size of the tree.

The general practice is to infect ⅓rd of the tree initially, the yield when the crop is cut is used to infect the next ⅓rd leaving some over for sale, and so on at successive seasons. The result is that the tree is constantly under lac without any rest and is regularly partly cut, twice a year.

Another practice is to give a preliminary small infection, which is allowed to self-infect at successive seasons until the tree is more or less fully covered. A certain amount of lac being cut at each season to bring in a small return. This method is not only extremely bad for the tree but also facilitates the breeding of insect enemies of lac.

Correct use.

To obtain the best results from Kusum the trees should be correctly pruned before use. When ready for infection they should be fully infected, and the crop when mature should be cut according to the methods explained in Chapter VI. The tree should then be rested until it is again ready for infection.

Rest necessary.

The rest period between pruning and infection, or cropping and infection depends upon the District and upon soil conditions. At Sabaya in the Ranchi District one year was found to be sufficient for trees growing on cultivated land (Tea Garden) after the initial pruning and again after a second pruning. Later results however show that although 1 year may be sufficient rest for some trees, 18 months is the more general rest period required.

On uncultivated land Kusum, pruned according to the methods advocated in this book, will be generally found to be ready for re-infection after a rest of 18 months. Trees growing on poor rocky soil however may require as long as 2 years rest after pruning or cropping. Such trees pruned heavily by the villager's method would require much longer rest peeriods.

Lac Cultivation on Kusum.

The following Table is a diagramatic representation of the use of Kusum, allowing 18 months' rest, Kusum can be satisfactorily used to carry either an Aghani or a Jethwi crop. Four coupes A. B. C. D. are necessary to make the area entirely self-supporting. While coupe A is in use, coupes B. C. D. are undergoing pruning and rest, so that they are ready for use in the season that they are required. By the time that D coupe has been infected and yielded a lac crop, A, which has been resting, is ready for infection.

TABLE XV

Coupe.	A.	B.	C.	D.
Prune ...	... Feb. 1936	July 1936	Feb. 1937	July 1937
Infect ...	... July 1937	Feb. 1938	July 1938	Feb. 1939
Cut and prune	... Feb. 1938	July 1938	Feb. 1939	July 1940
Ready for re-infection	... July 1939	Feb. 1940	July 1940	Feb. 1941

(Arrows indicate transference of brood.)

If 2 years' rest was found to be necessary an extra coupe would have to be added, if 1 year, only 3 coupes need be used.

Use of Kusum where July labour is scarce.

In some districts it is difficult to get labour in July to crop and infect, specially in districts where Kusum swarming occurs very close to the break of the Monsoon, at which time the raiyats are busy planting their own crops. The following method is one that gets over this difficulty; it necessitates natural infection at one season and is not therefore to be recommended except under circumstances that make it unavoidable.

The trees are infected in February with sufficient brood only, to give about 30%—40% coveration. In July, natural infection is allowed to occur so that the remainder of the tree, and any new shoots, are covered. The tree is then completely cropped in the following February. It will be seen that if 2 years' rest is found to be necessary, 3 coupes of trees will be needed, if only 1 year two coupes will be sufficient. Utilising this method 18 months' rest of course would never be given as the trees are, in every case, being infected at one season only, at intervals which are one year or multiples of one year in duration.

Advantages of a Kusum alternation.

The one difficulty with Kusum is of course the long rests which are necessary after pruning and after cropping, necessitating from 3—5 coupes according to the plan on which the trees are being utilised.

For example, assume 18 months' rest is found to be satisfactory, 4 coupes of Kusum are needed. If there are say 1000 trees in the area in question each coupe of 250 trees will be in use successively for 1 crop (i.e. 6 months approx.), and the whole 1000 will be used once in 2 years. It has already been explained that when Kusum brood is utilised to infect hosts other than Kusum, it behaves as if it were being grown on Kusum, and takes the Aghani and Jethwi cycles. If therefore a satisfactory host could be used in alternation with Kusum the value of the Kusum would be greatly enhanced.

If Kusum is allowed 18 months' rest, and used in alternation with another host, only 2 coupes are necessary each of 500 trees, which would be used in alternate crops, (in this case Jethwi crops). The whole 1000 Kusum would still therefore be used only once every two years, but in every second crop (Aghani) the alternate host would be under infection producing lac of the same quality and value as Kusum. The ideal host for this purpose is Khair, though Ber and certain other hosts can also be used similarly. The infection of Palas with Kusum brood is not to be recommended, though an Aghani crop can be raised on this host.

Alternations.

The use of these alternations is described in the chapters on Khair and Ber.

Rules to be observed in Kusum alternations.

In such alternations in all cases Kusum will carry the Jethwi crop and the alternative host the Aghani. In fact as a general rule *Kusum brood must only be used to infect non-Kusum hosts for the Aghani crop.* Experience over a number of years with a variety of hosts have made it abundantly clear at

Namkum that *the inoculation of hosts other than Kusum with Kusum brood in February for the Jethwi crop with few exceptions always results in failure.*

It may here be pointed out that there are two distinct strains of *L. lacca.* the Rangeeni and the Kusmi. This is extremely important in practice, the theoretical significance is discussed in Chapter XXII.

Kusmi and Rangeeni strains.

Kusum lac when inoculated on hosts other than Kusum maintains its characteristics and behaves in the Kusmi manner, and the resulting brood may be put back unto Kusum, because it is still the Kusmi strain although grown on hosts other than Kusum. The fact that a Jethwi crop cannot be grown with success on hosts other than Kusum using Kusum brood is not on account of the strain of lac but because the host tree is not capable of carrying lac at this time. The chapter on Khair makes this clear. A Jethwi crop has been raised experimentally on Ber at Namkum but was not satisfactory from a commercial point of view.

However if Kusmi lac is grown continuously on hosts other than Kusum, for several crops without being transferred back to Kusum, it eventually deteriorates and dies. Partly because this strain is not suited to hosts other than Kusum for more than one crop and partly because of the difficulty of raising a Jethwi crop on any host other than Kusum due to the unsuitability of most non-Kusum hosts for lac bearing throughout the hot weather.

The Rangeeni strain of lac does not take on Kusum and should never be used to inoculate Kusum trees. In practice this means that Kusum should never be infected with Palas or Ber brood at either Katki or Baisakhi seasons. The result of such infection is either that the lac dies almost immediately or that a *very* poor crop only is the result.

A further proof that Rangeeni is a different strain to Kusmi is that when Palas brood is inoculated on Kusum in July the lac usually dies, the indications are however that it would mature in October—November as it would on a non-Kusum host.

It will be seen therefore that both Rangeeni and Kusmi strains will live on hosts other than Kusum, but that only the Kusmi strain and not the Rangeeni will live on Kusum.

CHAPTER XI.

THE USE OF ACACIA CATECHU (Khair) AS A HOST TREE.

General.

Khair is, as has already been mentioned, a valuable and rapid growing host tree which under good conditions can be infected with lac $2\frac{1}{2}$—3 years from seed. It is a tree not used by the raiyat to any large extent for lac cultivation.

A. Catechu is a valuable tree in addition to its value as a lac host. Cutch and Kath are both obtained by boiling down chips of its heart wood. Cutch is utilised in India and is exported for dyeing and tanning. Kath is used in India for chewing with betel-nut. See also Chapter V.

Pruning.

A. Catechu is susceptible to heavy pruning and should therefore be lightly pruned using methods explained in the chapter on pruning. Early Institute publications recommended pruning of Khair in May, later work however has shown that while May pruning may be satisfactory for Khair under intensive cultivation, and only under occasional infection, March pruning gives in general much more satisfactory results.

Khair may however be pruned as late as April for July infection but if so should be pruned in the first half of the month.

Limitations, must only be infected in July.

In making use of this host it is extremely important to note that *Khair will not carry either a Baisakhi or Jethwi crop,* and that attempts to make it do so are certain to be failures. The reasons are as follows. Khair has not sufficient vitality in the late winter and early hot weather months to support a lac crop, the resting season falls between January and April and during this period there appears to be very little rise of sap in this host. The leaves provide little or no shade during the hot weather and afford no protection for a lac crop. The act of pruning or cropping of Khair in July also seems to be detrimental to the tree, and finally no matter when Khair trees are pruned they cannot be induced to throw out shoots which are entirely satisfactory for October-November or January-February infection. *Khair therefore should only be infected in July.*

Khair as a Katki host.

Acacia Catechu may be utilised as a Katki host in which case it should be infected in July with either Palas or Ber brood. A list of the yields obtained from the infection of Khair with Ber and Palas brood is given in Table XVI.

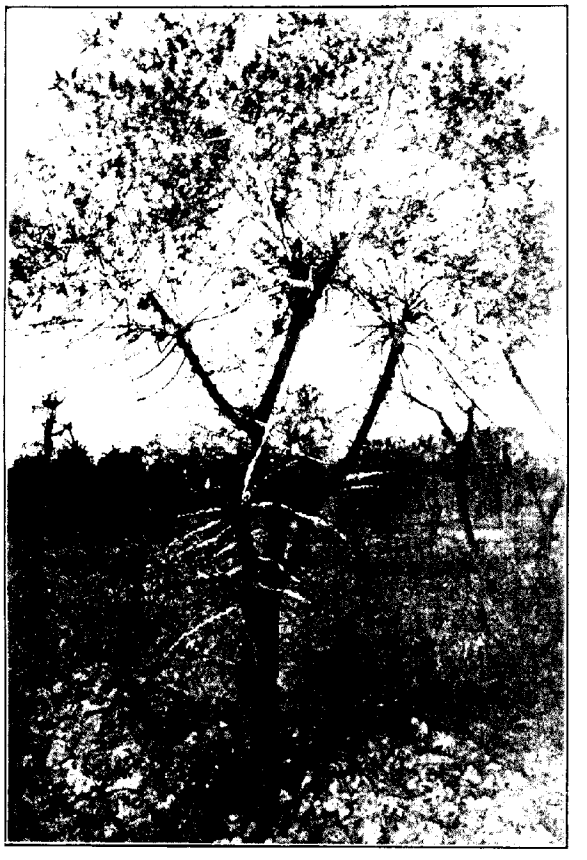


PLATE X

Acacia Catechu (Khair) infected with *Schleichera trijuga.* (Kusum) brood.
Namkum, Bihar.

TABLE XVI

Yields obtained by infection of Khair with Palas and Ber brood.

Crop.	*Strain.*	*Brood to yield ratio.*
Katki 1929	Palas × Khair	1 : 4·53 ; 1 : 3·85*
Katki 1930	Palas × Khair	1 : 4·6* ; 1 : 2·8 ; 1 : 2·9
	Ber × Khair	1 : 3·2
Katki 1931	Ber × Khair	failure.
Katki 1932	Palas × Khair	1 : 3·9
	Ber × Khair	very poor.
Katki 1933	Palas × Khair	1 : 3·0 ; 1 : 2·2*
	Ber × Khair	1 : 4·0 ; 1 : 3·6*
Katki 1934	Ber × Khair	1 : 2·5 ; 1 : 2·13*
Katki 1935	Palas × Khair	1 : 9·39*
	Ber × Khair	1 : 3·15
Katki 1936	Palas × Khair	1 : 3·74*
	Ber × Khair	1 : 3·7*

The brood obtained in October may be utilised for the infection of Palas or Ber. The lac obtained is very similar in quality to either pure Ber or pure Palas lac.

Khair as an Aghani host in alternation with Kusum.

The best use that can be made of Khair is its infection for the Aghani crop in July with Kusum brood. Kusum brood 'takes extremely well on Khair and the encrustation produced is equal in quality and quantity to that produced on Kusum, it does not however entirely surround the twig, long encrustations up to 4 feet and more in length are obtained. The brood produced as the result of the infection of Khair with Kusum (i.e. Khair prog. Kusum brood) commands the same price as Kusum brood and 'takes' extremely well, when used to infect Kusum in January—February. The stick lac produced by this Kusum × Khair inoculation is of the same quality as Kusum and can be sold as such for manufacture.

This is one of the best examples of a cross strain or alternation producing an extremely healthy resistant type of lac, and this alternation is one that should be utilised wherever both Kusum and Khair are available in the same vicinity.

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* Indicates that regular small samples of these lacs were taken for examination. Had this not been done slightly better yields would have been obtained.

The method of running such an alternation is to inoculate Khair in July with Kusum brood; and to cut the brood produced on Khair in February and put it back on to Kusum and so on. That is to say a continuous alternation, Kusum carrying the Jethwi crop and Khair the Aghani.

The Kusum will receive 18 months' rest after pruning or after infection and two coupes only will be necessary. Once the coupes are in use, crop cutting will in each case act as a pruning, and no pruning purely as such, need be done.

In the case of Khair, coupes are not necessary. The crop cutting in February acts as a pruning, and such trees will give out shoots which are suitable for infection the following July. Thus Khair receives $4\frac{1}{2}$ months' rest. Khair will apparently stand this treatment repeatedly. It is suggested however that, where there is plenty of Khair available, the trees might be rested after having had two to three successive crops taken from them in this way. It should be noted however that if any trees are found to have put out only poor shoots after this treatment they should be omitted, when carrying out the July infection.

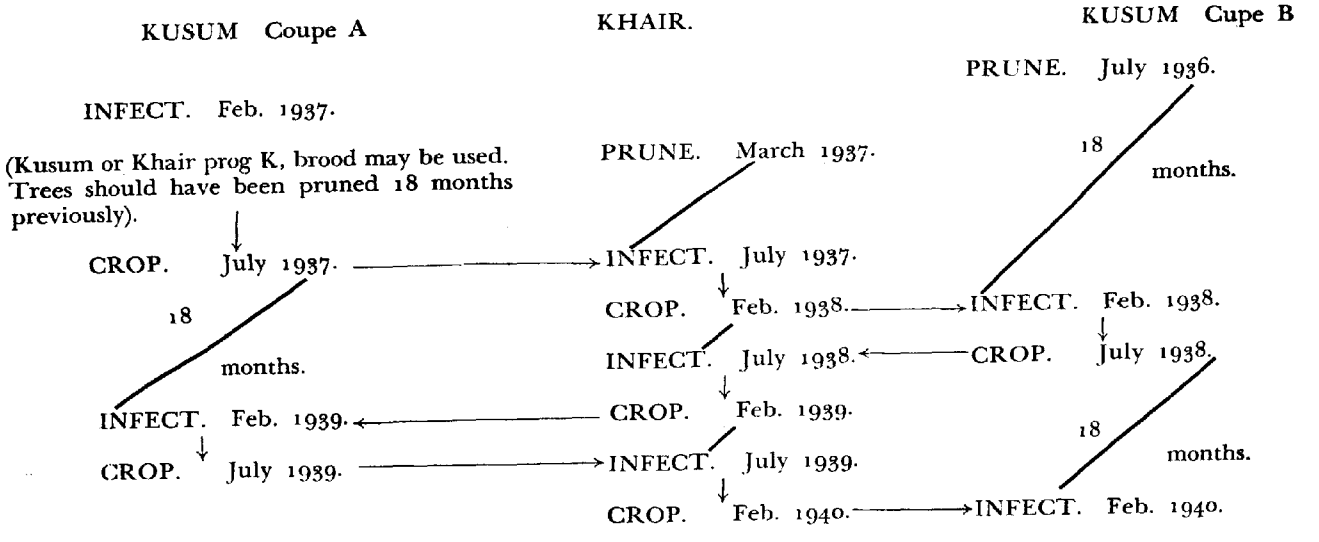
A simple diagram page 73 explains very clearly the method on which a Kusum x Khair alternation is run. Table XVIII gives the yields obtained by the inoculation of Khair with Kusum brood.

PLATE XI

Acacia Catechu (Khair) progeny of *Schleichera trijuga* (Kusum) lac Namkum, Bihar.

TABLE XVII

Diagram to illustrate the method of growing lac in alternation on Kusum and Khair.



AND SO ON.

TABLE XVIII

Yields obtained by infection of Khair with Kusum brood.

Crop.	*Brood.*	*Brood to yield Ratio.*
Aghani 1927-28	Kusum x Khair	1 : 1·9
Aghani 1928-29	Kusum x Khair	1 : 4·44
Aghani 1929-30	Kusum x Khair	1 : 4·62
Aghani 1930-31	Kusum x Khair	1 : 5·2 ; 1 : 5·0* ; 1 : 3·7
Aghani 1931-32	Kusum x Khair	1 : 8·4
Aghani 1932-33	Kusum x Khair	very poor.
Aghani 1933-34	Kusum x Khair	1 : 1·4* ; 1 : 1·1
Aghani 1934-35	Kusum x Khair	1 : 8·17* ; 1 : 8·16
Aghani 1935-36	Kusum x Khair	1 : 4·41*
Aghani 1936-37	Kusum x Khair	1 : 4·89

It will be seen from the above Table XVIII that very satisfactory yields are to be obtained by the infection of Khair with Kusum brood for the Aghani crop.

This infection has been carried out in a number of Districts and has given very satisfactory results, and is definitely to be recommended.

The theoretical consideration which arises from the above is that Khair is a host to both strains of lac the Rangeeni and the Kusmi, a discussion on this matter is included in Chapter XXII.

* Indicates that small samples of these lacs were regularly taken for experimental purposes. Had this not been done somewhat better yields would have been obtained.

CHAPTER XII.

THE USE OF BUTEA FRONDOSA (Palas) AS A LAC HOST.

General.

Palas is a semi-jungle and waste land tree, and is more used than any other by the raiyat for the cultivation of lac. It is extremely hardy and will withstand very rough treatment. According to Sir George Watt the word *lákshá* in the Atharvaveda denotes Palas, which is described by more recent Sanskrit writers as *lákshá-taru* or lac tree. It is commonly known also as the Flame of the Forest from its scarlet flowers, which appear when Palas is leafless in March—April, and in districts where Palas is abundant give the whole jungle a scarlet colour. The wood is of little value, and Palas has little commercial importance beyond the fact of its being a lac host. It is usually found growing in hot arid districts.

Palas is a Baisakhi Katki host exclusively. It can be inoculated with Kusum brood for the Aghani crop, and quite good yields can be obtained, this inoculation is not advised however. It should *never* be inoculated for the Jethwi crop.

Pruning.

Palas should be pruned in April—May for October infection. Infection in July is seldom done for reasons which will be explained. Pruning may be fairly heavy, and Palas will and does stand up to drastic pruning and even pollarding. Lighter pruning is however advised and it is suggested that shoots thicker than $1\frac{1}{2}$"—2" in diameter should not be cut.

Failure of Artificial infection in July.

It is a general, accepted fact and one that should be borne in mind by the cultivator that the artificial infection of Palas in July is always attended by failure in districts which are hot and arid. This is not due to the fact that rain occurring at the time when larvæ are emerging washes them away, nor is it due to the cutting off of the mother cell from her food supply.

Palas brood can be cut in July and used to inoculate Ber, for example. It cannot be that the shoots resulting from April—May pruning are not suitable for larval settlement as the shoots resulting from partial pruning at this time are suitable for infection. Whatever the reason, practical experience supports the inadvisability of artificial infection of Palas in July.

At Namkum it has been possible to inoculate Palas with either Palas or Ber brood in July and get good results. Palas however in general grows in hot arid districts and attempts should not be made to carry out artificial infection in July in such places.

Leaf stalk.

Palas trees are leafless in March-April and therefore all lac insects which attach themselves to the leaf stalk in the Baisakhi crop are unable to reach

maturity as they fall with the leaf prior to this. When prices are high the leaf stalks are collected, and being too thin to scrape, are cut into short pieces of $\frac{1}{8}$"—$\frac{1}{4}$" long, these are often added in with the Baisakhi crop to increase its bulk. This is a bad practice and should not be allowed, at present prices however it is unlikely to occur. If leaf stalk is collected in this way it should not be mixed with the scraped lac, but should be sold separately as such.

In the Katki crop, the lac insects swarm on to the leaf stalk, but as the leaves are not shed during these months the lac reaches maturity and even when the brood is cut, the stalks do not break off. This is made use of when inoculations for the Baisakhi crop are done ; the leaf stalks on the brood sticks arising as they do at an angle, are used as hooks, and brood sticks with several stalks can be interlaced between the new shoots, being held in position by the leaf stalks alone ; this saves the use of a certain amount of string and also a good deal of time which is important when some thousands of trees have to be infected.

Method of using Palas.

The general principle of lac cultivation on Palas in hot arid districts is as follows.

Trees to be inoculated are pruned in April—May, and are infected the following October with Palas or Ber brood. The following April—May the lac is partially cut, usually 2/3rds are cut and 1/3rd is left. The 2/3rds is sold ari, as stick lac. In cutting the 2/3rds, all dead and unhealthy lac is first chosen for cutting, the 1/3rd that is left being the most healthy lac. The 1/3rd also, is left as far as possible so that it is protected by the leaves and branches from the sun and hot wind, usually towards the centre and upper part of the trees.

At this time any trees found bearing dead or unhealthy lac, should be completely cropped.

The reasons for this have been fully explained elsewhere, briefly:—

(1) By this time resin secretion has almost finished in the Baisakhi crop so this cutting involves practically no loss.

(2) The trees during the hot weather frequently cannot stand the drain put upon them by a full lac crop, but can stand that of a 1/3rd crop only.

(3) The risk of theft and consequently cost of chowkidars, is greatly diminished.

Any trees bearing only dead lac are completely cropped at this time.

This partial cutting acts as a pruning and new shoots are put out. In July the one third lac that has been left is allowed to swarm *in situ* (Natural infection) the larvæ which emerge settling on the new shoots arising from the April—May partial cutting.

In October the entire crop is cut and utilised to infect fresh trees.

TABLE XIX

May	Prune.
October—November	Infect.
April—May ... ... (usually May).	Cut 2/3rd lac leaving, 1/3rd for natural infection in July.
July	Natural Infection allowed.
October—November	Reap the crop.

Trees cropped in October—November will generally require repruning the following May before infection the following October—November.

To cultivate lac on Palas in this way it would be necessary therefore to have two coupes, one in use for the Baisakhi and Katki crops, the other ready for inoculation in October when the first is completely cropped.

This method is satisfactory in districts in which the weather is not extremely severe, and in which the majority of the Palas trees will carry lac through to brood in July.

Brood producers and Non-Brood producers.

In many Districts where the hot weather is extreme, only a small percentage of the Palas will carry lac through the hot weather to give brood in July, inspite of the 2/3rd partial cutting in April—May. These trees will be called *Brood Producers,* those that will not carry brood, *Non-brood producers.*

The actual percentage of brood producers among the trees varies from year to year, the milder the hot weather the greater the percentage of brood producers and *vice versa.* It is also interesting to note that brood producers are most generally found, on or close to cultivated land, in sheltered situations where they are shielded to some extent from the hot winds, and above all in situations where sub-soil moisture might be excepted. In the Kundri lac orchard, which is entirely Palas, there are a number of large tanks, these dry up in the hot weather. In a bad year it is noticeable that brood producers are almost always found in the vicinity of the tanks, where although the tanks themselves have dried up sub-soil moisture is likely to occur.

This matter is being investigated in conjunction with the Forest Department as it seems probable that a scheme, such as interconnecting trenches by which the area over which the water lies is increased, thereby increasing sub soil moisture, would probably be very beneficial in increasing the percentage of brood producers among the trees.

Use of Palas in very arid Districts.

Where the percentage of brood producers among the Palas is small, the two coupe system may be a failure, due to the fact that when divided among two coupes, the number of brood producers in each may be so small as to be unable to produce enough brood for the infection of the second coupe in the following October.

Further as in general practice a really successful Palas crop occurs only about once in every three years, it is desirable to have as many trees as possible infected when the good year arrives.

Palas should be divided into three categories, as result of experience.

A. Brood producers.

B. Brood producers in a good year.

C. Non-Brood producers.

When infecting, brood producers will be infected first, then brood producers in a good year and finally all brood left over after infecting A and B will be used to infect non-brood producers.

The trees should then be worked as follows. In October infect as many trees (previously pruned in May) for which there is brood available, in the order given above. *All* brood producers being infected first, then all brood producers in a good year and so on.

In April May during 2/3rd partial cutting, all non brood producers are completely cropped. On the remainder the 2/3rd cutting is carried out as already explained.

In a bad year on only brood producers Class A, lac will survive. In more moderate years, a percentage of brood producers, Class B will carry lac to brood in July, the percentage depending on the severity of the year in question. In a moderate to good year, therefore a number of brood producers Class A may be completely cropped in May and will be available for infection the following October. This may safely be done in a moderate to good year as on many of the brood producers Class B, lac will survive to act as brood in July.

In July natural infection is allowed to occur on all trees, (except of course on trees completely cropped in April-May which will of course bear no lac at this time).

In October brood producers Class A are again partially cropped 2/3rds the lac being cut and 1/3rd being left for natural infection, when cropping however, any trees which are fully infected and on which there is no space for larvae to settle, should be completely cropped. The 2/3rd lac which has been cut is utilised to infect fresh trees in the order given before, first any brood producers

Class A which are uninfected or under infected, secondly brood producers Class B and thirdly non-brood producers.

This method of cultivation allowing continuous natural infection of brood producers Class A is against the advice in general laid down in this book, but is unavoidable in hot arid Districts where the percentage of brood producers among the trees is low.

In actual practice due to the fact that one good crop in three only is the general rule, and the capacity of a tree to act as a brood producer of Class A or B is not absolutely fixed, continuous natural infection does not occur as frequently as it might be supposed.

In-breeding

Continuous in-breeding tends to weaken the stock and it is suggested that fresh brood either Palas or Ber should be introduced from elsewhere either by purchase or better still by exchange at the end of every third year, *i.e.*, after the sixth crop.

Palas alternations.

Palas brood can be used in moderate Districts as for example the Ranchi District, to infect Ber in July. The resulting brood being used either again on Ber in October or put back on to Palas. This crossing of strains is extremely beneficial and should be utilised wherever possible.

Palas brood may be utilised to inoculate Ber in October, this is the common practice in Districts such as Daltonganj and Manbhum where Ber will not carry Baisakhi lac to brood in July, the lac being cropped as stick lac in April May and the Ber reinfected with Palas the following October.

Palas Brood should *never* be used to inoculate Kusum. It can be used on a number of other lac hosts, for example on Khair in July. It can also be used to inoculate certain of the minor lac hosts as for example Panjan. Its use in this connection is recounted in Chapter XIV.

CHAPTER XIII.

THE USE OF ZIZYPHUS JUJUBA (Ber) AS A LAC HOST.

General.

Ber is a fairly rapidly growing tree and one that is used to a large extent by the villager as a lac host, it is not a jungle tree and is usually found growing round villages or on cultivated land. The wood is of little value, the fruit, plums, bring in a small revenue, it does not grow to a very great size.

Ber in districts where the temperature in the hot weather is not excessive for example, Ranchi can be utilised for both Baisakhi and Katki crops and will give brood in July. It may also be alternated with Kusum for the Aghani crop. Ber should *never* be inoculated with Kusum brood in January-February for the Jethwi crop.

Use of Ber in temperate Districts.

In temperate Districts, Ber may be used for both Baisakhi and Katki crops. Trees should be pruned in March-April for July infection and in April May for infection in October-November. Three coupes will be needed, the first being infected in July for the Katki crop and reaped in November, this coupe will be ready for re-inoculation the following July and may, or may not, require repruning in March-April, unless heavy growth has been put on repruning will in all probability be unnecessary. The second coupe will be used for the Baisakhi crop and will be cut the following July, the brood being used to re-infect the first coupe. The Baisakhi coupe is not likely to be ready for re-infection in October-November and so a second coupe will be necessary for use in alternate Baisakhi crops. The Baisakhi coupes after cropping in June-July, will require repruning the following April-May before reinfection in October-November the next year. Thus one coupe is used for each Katki crop and the other two alternately for the Baisakhi crops.

Use of Ber in arid Districts.

In more arid districts the practice during the Baisakhi crop is to cut the crop from some trees in April-May, leaving a certain number of trees only, fully or partially inoculated to give brood lac in July. In some Districts Ber is $\frac{2}{3}$rd cropped in April-May, as is Palas. In July the brood is cut and transferred to a fresh coupe of trees for the Katki crop. The cutting of the trees in April-May acts as a pruning, and trees that have been thus treated are reinfected the following October-November. Natural infection is not usually permitted on Ber even by the raiyat and should not be allowed.

In Districts where intense heat occurs in April and May such as Daltonganj and Manbhum, lac will not survive on Ber to give brood in July and the whole crop is therefore cut for sale as stick lac in April-May. The trees are then re-inoculated in October-November with Palas brood.

Ber utilised as a Baisakhi Katki host may be inoculated with either Ber or Palas brood, the references made previously to the use of cross strains may be seen in this connection, this is a case where a cross strain is frequently found to be extremely beneficial. **Ber alternations.**

Ber brood can be used to infect Khair in July and on Palas in either July or October. Ber brood should *not* be used to inoculate Kusum.

Ber brood may also be used on a number of minor lac hosts as for example *Panjan, Ficus sp.* etc. Its use in this connection is recounted in Chapter XIV.

The reason why Ber is a poor Baisakhi host in hot arid districts is that the resting period occurs during the months March to May, during which time the trees are leafless, hence the lac receives no protection from the sun and hot winds, and there is little rise of sap. **Light pruning of infected Ber.**

It has been shown at Namkum that a light pruning of infected trees in February after male emergence is very beneficial, it does away to some extent with the resting period, promoting an earlier output of young leaves. Trees thus treated gave better yields in every case than did control trees.

When carrying out this light pruning, the main lac bearing shoots are left, and the smaller lateral branches cut, whether they bear lac or not. Naturally any branches bearing dead or unhealthy lac or being covered largely by male cells should be cut at this time.

In a mild year the beneficial effect of partial cutting is very small, it is in a hot arid year that it has the greatest beneficial effect. It is of course impossible to tell in January-February when partial pruning is done whether the year will be good or bad, therefore partial pruning may be done in any case. An Institute bulletin on this subject is in preparation.

That moisture is one of the deciding factors in brood survival during the hot weather has been amply proved at Namkum over a number of years. Two groups of Ber trees were taken, one group was watered daily throughout the hot weather, the other was kept as control. In July it was found in each case that the survival on the watered trees was much greater than on the control trees. The lac on the watered trees being largely healthy brood lac, while that on the control was to a considerable extent stick lac. **Importance of moisture.**

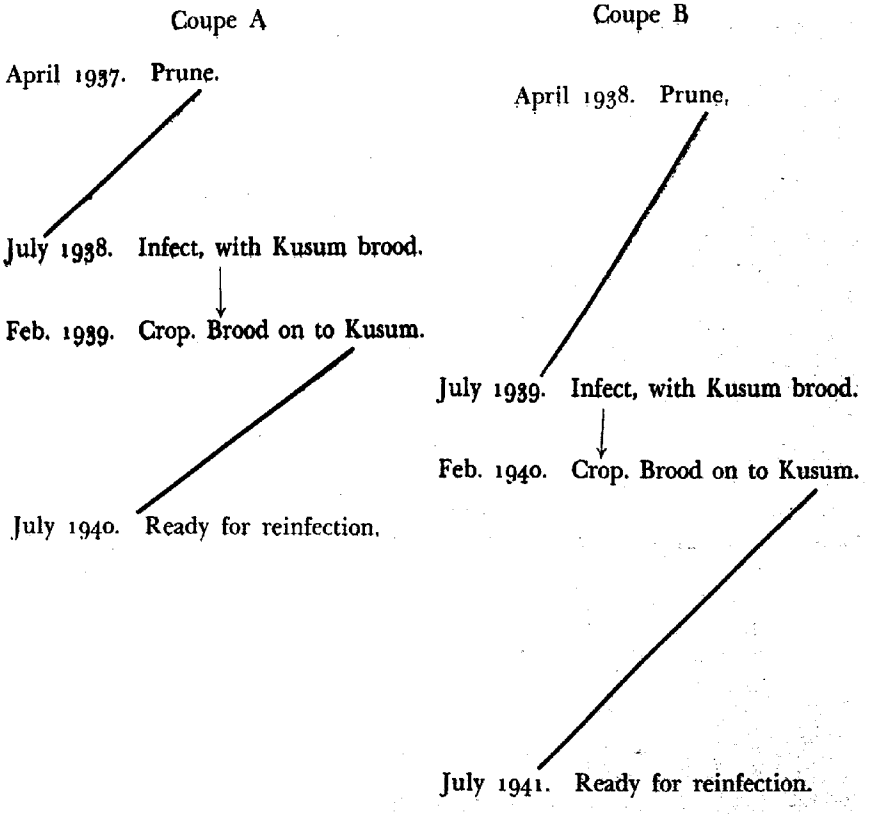
Ber as has already been mentioned may be inoculated with Kusum brood in July, for the Aghani crop. It should *not* be used for the Jethwi crop. Kusum on Ber however is an inoculation rarely carried out by the raiyat and is not on the whole to be recommended. The results obtained are not in general anything like so good as those obtained from the inoculation of Khair **Ber in alternation with Kusum.**

with Kusum brood, the crop is usually rather heavily predator affected and the resulting brood (Ber prog K) in February is not so good as Khair progeny Kusum brood for the inoculation of Kusum.

When used in this way Ber should be pruned 15 months prior to inoculation, i.e. for infection in July 1937 trees should have been pruned in April 1936. After cropping, the trees should be rested 18 months prior to reinfection i.e. crop in February 1937 reinfect July 1939. (N.B. These periods are only intended for Ber inoculated with Kusum brood and are *not* satisfactory for Ber as a Katki Baisakhi host).

Except for the longer resting period required by Ber, this alternation is run exactly in the same way as a Kusum X Khair alternation. Ber would in this case have to be divided into two coupes as follows:—

TABLE XX



CHAPTER XIV.

LAC HOSTS OF MINOR IMPORTANCE.

It is quite impossible in a book of this sort to discuss all the known lac hosts. It is proposed in this chapter to give an account of some of the more important of the minor lac hosts, and to record results which have been obtained as regards them at this Institute.

Zizyphus Xylopyra (Ghont).

Zizyphus Xylopyra (Ghont). It has already been stated elsewhere that except in Central Provinces, United Provinces and the Punjab, Ghont is not a satisfactory lac host. It is a host of real importance only in Central Provinces. Ghont introduced at Namkum has failed to yield a lac crop, in spite of pruning at diverse dates and infection with a large number of different types of brood.

Cajanus indicus (Arhar).

Cajanus indicus (Arhar). Arhar is an important last host in Assam, this appears to be largely accounted for by climatic conditions, which are moist and humid throughout the year, and Arhar is grown as biennial and triennial crop. In Chota Nagpur any attempt to utilise Arhar as a host during the Baisakhi crop, (Arhar is sown in June) results in failure, whether infected or not, numbers of plants usually die during the hot weather months, (Arhar seeds in March). If infected with lac, the plants usually die early in the hot weather, if they do survive, the lac usually dies in the heat of April-May, though it may frequently survive as long as the first week in April.

Arhar in Chota Nagpur is an annual crop, and is resown before each Monsoon. Of plants left in the ground for a second year, some survive to the Monsoon but infection with lac for the Katki crop does not give good results, plants thus treated usually die, or if they survive do not yield a satisfactory crop.

It is possible that Arhar growing in districts which are humid throughout the year, such as some parts of Bengal might be utilised as lac hosts. Experiments should be made on a small scale only in the first place. Attempts to use Arhar as a host in dry arid districts are certain to be failures.

The infection of Arhar with Kusum brood is *not* satisfactory.

Arhar is however being further investigated at Namkum.

Ougeinia dalbergioides (Panjan).

Ougeinia dalbergioides (Panjan). Lyall in his Notes on Lac Cultivation (1928) states that in the Daltonganj area its behaviour is somewhat like that of Palas, and that it grows practically exclusively under forest conditions. He states that the seeds are almost always infertile which is at variance with results obtained at Namkum.

Panjan has only recently reached an infectable age at Namkum. It would appear to be a good Baisakhi host using either Palas or Ber brood. The following yields were obtained during the Baisakhi 1934-35 crop. Palas × Panjan 1:5·0. Ber × Panjan 1:2·0. It can also be used as a Katki host, Ber × Panjan during the Katki 1936 gave a yield of 1:2·23.

Panjan may be inoculated with Kusum brood for the Aghani crop also, yields of 1:3·65 and 1:1·97 having been obtained respectively in the Aghani 1935-36 and 1936-37 crop.

Panjan should *never* be used for the Jethwi crop.

Albizzia stipulata (Siris).

Albizzia stipulata (Siris). This tree is frequently found as a shade tree in tea gardens in the Ranchi District. Mr. Bates, Manager Palandu Division, Assam Frontier Tea Company had some success at Sabaya inoculating Siris with Palas and Ber brood for Baisakhi and Katki crops and was able to obtain brood lac in July and October. Self inoculated trees also gave some quite good yields. It was however observed in almost every case inoculated trees died either while still under lac or soon after cropping.

Seed from these trees was planted at Namkum. Inoculation of the resulting plants has resulted in failure in Katki Baisakhi and Aghani crops. Inoculation of *A. stipulata* is not therefore to be recommended.

Albizzia lucida.

Albizzia lucida. This host has been planted at Namkum and has only recently attained a size sufficient for infection. It can be used either as a Baisakhi, Katki or Aghani host. The following yields were obtained.

Baisakhi 1934-35.		*Katki 1936.*		*Aghani 1935-36.*	
Palas × *A. lucida*	1:4·0	Palas × *A. lucida*	1:1·28	Kusum × *A. lucida*	1:8·1
Ber × *A. lucida*	1:2·0			(all Aghani infections gave high yields in 1935-36).	
				Aghani 1936-37.	
				Kusum × *A. lucida*	1:1·84

Acacia moniliformis.

Acacia moniliformis. An host in the Sambalpur District is worth mention, the tree is very rapid growing and at 3 years old was 18 feet high, it is an evergreen with scandent (weeping) habit. Infected with Palas brood it produced quite a fair crop.

Acacia arabica (Babul). Although Babul occurs in Bihar, it is not a satisfactory lac host. Several botanicaly distinguishable strains of Babul occur in India which may explain this. **Acacia arabica (Babul).**

It is however an important host in Bombay Presidency and Sindh, and to a lesser extent in the Punjab. It occurs also in Madras and Bengal.

It occurs mainly along canal banks, on lands flooded annually, or on land where there is some sub-soil moisture. It will carry either Baisakhi or Katki crops, the former suffer badly in the Hot Weather ; Babul brood is said to be the best for inoculation of Babul ; Kusum brood however will take on Babul and gives good results ; it may therefore be possible to alternate Babul with Kusum as has been done with Khair.

Dalbergia sps. The results of the infection of *Dalbergia sps* are rather inconclusive. *Dalbergia sisoo* in spite of constant infections has never given a satisfactory result, and may be classified as a non-lac host. **Dalbergia sps.**

Dalbergia latifolia and *D. lanecolaria* have proved failures for the Katki and Baisakhi crops after repeated infections. Both hosts infected with Kusum brood for the Aghani 1935-36 crop gave remarkably good yields (1 : 8·25 and 1 : 12·88). This being the first yield they had given in spite of repeated infection. It may be mentioned here that all yields during the 1935-36 Aghani crop were high. This behaviour was not maintained during the Aghani 1936-37 crop, when infection of *D. lanecolaria* and *D. latifolia* resulted in such poor yields that the infections could only be termed failures.

Grewia lævigata. This species is to be classified as a non-lac host in this District. **Grewia lævigata.**

Kydia calycina. The yields obtained from the inoculation of *K. calycina* at Namkum have been extremely poor and this species can only be classified as a failure as a lac host. **Kydia calycina.**

Acacia Farnesiana (Kastura). This species grows rapidly, it can be sown in Nursery Beds and transplanted, or it can be propagated from root, and shoot cuttings. **Acacia Farnesiana.**

A. Farnesiana has not proved a very satisfactory lac host and yields are small. It can be inoculated in June-July with Palas or Ber brood for the Katki crop, having been previously lightly pruned in March. It will also carry a Baisakhi crop, Palas or Ber brood may be used for infection, in a good year. Yields of 1 : 2·0 were obtained during the Baisakhi crop.

In certain years quite good crops have been obtained by inoculating with Kusum brood in July for the Aghani crop. Crop cutting in February acts as a pruning and the trees can be re-infected in July.

It is advisable to infect this host lightly as trees are easily killed by over heavy infection.

Flemingia congesta.

Flemingia congesta. A well-known Assam shrub host. *F. congesta* is a poor host in this District. Infection with Kusum brood results in failure. Yields have been obtained by infecting March pruned shrubs with Ber or Palas brood for the Katki crop. In a good year it is possible to raise a Baisakhi crop on *F. congesta* using Ber or Palas brood.

Ficus sps.—

Ficus sps.

1. *F. glomerata* (Dumber, Fig. Gular).
2. *F. infectoria* (Pakaur, Pakri).
3. *F. glabella* (Putkul).
4. *F. religiosa* (Pipal).
5. *F. Cunia* (Porho).

A number of other species of *Ficus* trees can be used as lac hosts also. The quality of the lac produced is not good but a number of them seem to have the power of carrying lac in the Baisakhi crop to brood in July and in this lies their value. With Dumber, results were not very satisfactory although small amounts of brood were produced in July, (Baisakhi infection of this species at Sabaya was a failure), Porho and Pipal have successfully done this at Namkum, and to a less extent Pakaur and Putkul. This suggests the use as July brood producers of those that will carry brood through the hot weather, they can be inoculated with Palas or Ber brood in October—November and the brood obtained in July can be put on Ber or other hosts. It is suggested that each individual cultivator should make a trial with the *Ficus* hosts at his disposal on a small scale on the lines above suggested. Once their behaviour in his own particular neighbourhood is discovered the infections can be increased or dropped as results show.

The quality and yield of lac produced is poor and at the present prices the infection of *Ficus sp* with lac is not done to any large extent.

Pipal and to a less extent Porho may be infected with Kusum lac for the Aghani crop. The former infection produces lac of quite a high quality and the yields obtained are quite satisfactory.

Pruning should be done in March—April for July infection and April—May for infection in October.

Anona squamosa (Custard apple). All infections on this species proved a failure, the trees at Namkum were adversely affected by lac infection. **Anona squamosa.**

Atylosia albicans. The host is a creeper, fair results were obtained by inoculating it with Kusum brood for the Aghani crop. **Atylosia albicans.**

Among other minor hosts, *Nephelium litchi* is said to produce encrustations of the Kusmi type, as this host is a valuable fruit producer, its inoculation with lac is inadvisable. *Pithecolobium Saman* the rain tree produces thick rather brittle reddish coloured lac in South India. Attempts to introduce *P. Saman* at Namkum have not been satisfactory, young plants several years old are only a few feet in height and there has been heavy mortality. This is almost certainly attributable to the extremely dry climate in this District. Good encrustations have been seen also on *Croton oblongifolius*, a number of plants of this species have been raised at Namkum from rhizomes, infection of these plants has so far resulted in failure.

There are indications that the infection of *Acacia canescens* and *A. pennata* with Kusum brood for the Aghani crop will produce good results.

Infections of *Shorea talura* (Jalla) at Namkum have not yielded results of any great importance. Small yields have been obtained during the Aghani and Katki crops. The most interesting result with this host has been that it has been shown to give rise to only two lac crops in the year in this district, whereas in Mysore it carried three crops in thirteen months.

CHAPTER XV.

LAC CULTIVATION IN CENTRAL PROVINCES.

Reporting areas. After Bihar, Central Provinces is the second most important lac producing area in India. Crop reports are received from the following centres in order of importance, Gondia (Palas lac) Kota-pendra (Palas lac), Rajim-Dhamtari (Palas and Kusum lac) and Katni-Damoh (Palas and Ghont lac). Reports are also received from: Raigarh-Champa ; Naita-Rajnandgaon ; Saugor-Harpalpur and Itarsi-Bankheri.

Production. The estimated production is in the neighbourhood of one and a half lakhs of maunds per annum, out of which about 30,000 maunds are kusmi. This includes lac grown departmentally by the Forest Department, lac produced on land other than by the Forest Department such as malguzari and zamindari areas. It also includes lac sold in for example the Dhamtari market, grown in Indian States in the vicinity.

Hosts. The main host trees are *Butea frondosa* (Palas), *Schleichera trijuga* (Kusum) and *Zizyphus Xylopyra* (Ghont) which grows in very large numbers in the Damoh district. An interesting point in this connection is that Ghont in the Ranchi District is not a lac host. A large number of Ghont have been grown from seed obtained from the Central Provinces at Namkum and in spite of repeated infection with various broods and pruning at different times, it has been impossible to get these trees to bear a lac crop. (For further discussions see Chapter XXII).

Other hosts occurring in Central Provinces are *Acacia Catechu* (Khair), *Zizyphus Jujuba* (Ber), *Acacia arabica* (Babul), *Ficus infectoria* (Pakur), *Acacia pennata, Ficus religiosa* (Pipal), *Dalbergia latifolia* (Shishum), *Ougeinia dalbergioides* (Tinsa), *Albizzia odoratissima* (Airma bonsa), (I have seen quite healthy samples of encrustation on this host) and *Cæsalpinia coriaria* (Angrezi imli).

Crops. The Baisakhi and Katki crops are of roughly equal commercial importance in Central Provinces, unlike Bihar where the Baisakhi is the major commercial crop. The reason for this is that the Baisakhi crop has to undergo an extremely hot and arid hot weather and usually suffers considerably. The host, Ghont, is low in vitality, and losses its leaves in February—March and thus is able to proivde little shade for the protection of the lac crop. The Baisakhi crop has therefore to be utilised as a brood crop for the Katki. The Katki crop extends from July to November and the Baisakhi from November to July.

In the Damoh district Ber, Khair and Palas brood will take on Ghont and Ghont brood may be used to infect Ber, Khair and Palas, Ghont brood is not successful on Kusum, and Kusum brood is not used to infect Ghont.

Cultivation on Ghont.

The method of cultivation on Ghont is crude, but is partially enforced by the lack of labour, a difficulty which the Forest Department has been trying to overcome. Brood is not tied to the trees but is roughly interlaced among the branches, a medium sized tree receives about 1½ seers of brood, after infection the tree is allowed to re-infect naturally until there is no further room for the lac to settle, it is then cropped, when it may yield up to 5 seers. The tree is then left until new shoots have grown. In practice this means that the trees carry three successive crops and then are rested for three years. Due to shortage of labour only about 30% of the possible area is under cultivation. There is a distinct prejudice among certain classes against lac cultivation as it necessitates the taking of life, and only the lowest classes and aboriginal tribes will undertake the work.

Damoh District.

A lot of natural infection is noticed outside the area purposely infected, and it is believed that the insects can fly or are carried by wind or birds. The insects of course cannot fly, wind and birds may account for these infections, but I should suggest that human agency has something to do with this.

In the Damoh Division a light fire is allowed to pass over the areas to be infected in Katik, in the month of October with a view to minimizing destruction by fire in the hot weather. This is reported to have given good results.

The lac crop from the Damoh District is sold as soon as possible after collection, it is disposed of by auction and the whole practically finds its way to Mirzapur for manufacture.

Saugor Division.

In the Saugor Forest Division most of the lac cultivation is done by the Forest Department, although in certain areas of the Deori Range a caste called *lactoras* cultivate lac in malguzari areas chiefly on Ber. No contractors are allowed to cultivate lac in reserved forest in this Division. The production of the Damoh and Saugor Forest Divisions is said to be 2,500 maunds at the present time. In addition to the hosts already mentioned *Dalbergia paniculata* (Dhoben) and *Ficus Bengalensis* (Bargat), carry good infections in the Saugor Division.

Only the Katki crop is collected, the Baisakhi crop being used as a source of brood supply, the host trees are lightly, but uniformly infected in November to ensure that there is sufficient area left on the tree for natural infection the following July, the whole lac crop being collected in the November following. The principal host tree so far is Ghont, but under the lac scheme recently introduced, Palas, Ber and Khair are also being used with, so far, very good results.

The chief difficulty in this division against the spread of lac cultivation is labour, and to overcome this forest villages are being formed wherever possible.

Raipur District.

No lac is cultivated in the three Ranges of the Bilaspur Sub-Division. Lac is grown in the North Raipur Forest Sub-Division where the work is carried out by forest villagers under supervision of the Forest Department. It is collected from them and sold through the D. F. O. Raipur either at Dhamtari or Damoh. The yields during the last 5 years to the nearest maund are given as follows: —

1932-33	...	...	... 7 maunds
1933-34	...	...	... 6 „
1934-35	...	...	... 9 „
1935-36	...	...	... 7 „
1936-37	...	...	... 19 „

Lac is cultivated on *Butea frondosa* (Palas) and *Schleichera trijuga* (Kusum). The Katki is the main crop and is collected from October onwards. The hot weather is too severe generally for the production of a good Baisakhi crop.

In the Bhandara district lying between Nagpur and Raipur, *Butea frondosa* (Palas) is the main host. Two types are said to occur separable by their bark, one type, a good lac host having a rough dark bark and the other a poor lac host having a smooth lighter coloured bark. Brood is tied to the hosts and the trees are cropped entirely and allowed to rest when they are fully covered. A large tree is said to require 2 seers of brood and to yield as much as 15 seers when cropped.

The bulk of the lac grown in the Raipur Division is grown Departmentally by the Forest Department. The major portion of the lac sold in the Dhamtari market is produced by the various Indian States adjoining this District.

In South Raipur, *Schleichera trijuga* (Kusum) is an important host. The trees are artificially infected; well covered trees are cropped entirely and allowed to rest for $2\frac{1}{2}$ years; lightly covered trees are allowed to self-infect and are then cropped and rested at the next season. Kusum lac is also grown in the Hoshangabad and Narsingpur Districts. The swarming dates of Kusmi lac in the Central Provinces are said to be July and late November—December.

I should like to thank the Conservator of Forests and Divisional Forest Officers, Central Provinces for their kindness in helping me to collect this data.

CHAPTER XVI.

LAC CULTIVATION IN BENGAL, AND IN PROVINCES OF MINOR IMPORTANCE.

Bengal.

In Bengal the major lac growing areas are Malda and Murshidabad. Host plants are *Zizyphus Jujuba* (Kul); *Acacia arabica* (Babla); *Ficus glomerata*, (Dumber); *Ficus infectoria* (Pakur); and *Ficus religiosa* (Pipal): Lac is said also to be be cultivated on *Cajanus indicus* (Arhar) in the Nawabganj district. *A. arabica* is apparently little used as a lac host. The crops grown are Baisakhi and Katki, both natural and artificial infection are employed. The Baisakhi crop is largely reaped in between the middle of April and early July, leaving sufficient lac on the trees to reap in July for the infection of fresh hosts. The Baisakhi is the major crop the Katki being largely a brood crop for the Baisakhi. *Zizyphus Jujuba* is the main host.

There seems to be scope in Bengal for the use of either *A. arabica* or *Ficus sps.* in alternation with Ber, the former being utilised for the Baisakhi crop.

The production of lac in the Malda District during the last five years has fallen from 20,000 maunds in 1931 to 10,000 maunds in 1935. From 1926 to 1930 the production fell from 60,000 maunds to 30,000. The production of Murshidabad was reported to be 79,000 maunds in 1935. The production of lac in Bengal as a whole may be taken to be 80,000 to 90,000 maunds at the present time.

The Punjab.

The major area of lac cultivation in the Punjab is Hoshiarpur, minor centres are Ambala, Kangra and Gurdaspur. Lac is also grown in small quantities in Sialkot, Jullandur, Ludhiana, Karnal, Yhang Gurgaon, Rohtak, Rawalpindi and Amritsar.

Systematic cultivation is however carried on practically only in the Hoshiarpur District. The total quantity of lac produced lies roughly between 8,000 and 12,000 maunds per annum.

Lac hosts in order of importance are the following *Zizyphus Jujuba* (Ber); *Zizyphus Xylopyra* (Ghont, Malhar); *Acacia arabica* (Kikar); *Butea frondosa* (Dhak. Chhichra); *Acacia Catechu* (Khair); *Ficus Carica* (Fig); *Ficus glomerata* (Gular); *Albizzia lebbek* (Siris); *Ficus religiosa* (Pipal); and *Ficus Bengalensis* (Banyan).

Two crops are grown, the Hari, October-November to June, corresponding with the Baisakhi crop, which is the major crop, and the Katki crop June to October-November.

Cultivation is very haphazard ,and natural infection is allowed, or sticks of brood are placed indiscriminately on the trees. The reason for Hoshiarpur being a major centre of cultivation is probably due to the fact that it is sheltered to some extent from the hot winds by the Siwaliks. Hosiarpur produces by far the greater part of the lac grown in the Punjab. Ambala, Kangra and Gurdaspur produce a few hundreds of maunds each and the remainder very small quantities only.

United Provinces.

In the United Provinces lac is grown in a restricted area, expansion being prevented by climatic conditions. Lac is grown in the Garhwal Forests and Saharanpur and some other districts in the Meerut, Benares and Jhansi Divisions. The important reporting area is however Mirzapur. The annual production is in the neighbourhood of 5,000 maunds.

Host plants of importance are *Butea frondosa* (Palas); *Zizyphus Xylopyra* (Ghont); *Acacia arabica* (Babul); *Zizyphus Jujuba* (Ber); and *Ficus sps.* The crops are Baisakhi and Katki.

In the Etawah District Cawnpore good encrustations have been observed on *Acacia leucophlaea.*

Mirzapur is one of the most important centres of lac manufacture in India.

Bombay.

In Bombay the only areas of lac production are the Karachi Division and Dharwar-Bijapur Divisions. Hosts reported are Palas, Ber, Babul and Khair and in addition *Dichrostachis cinerea, Albizzia amara, Acacia latronum, Acacia concinna* and *Ficus tsiela.* The annual production of Bombay Presidency and Baroda is between 7,000 and 11,000 maunds.

Rai Bahadur C. S. Misra in his "The Cultivation of Lac in the Plains of India" quotes *Zizyphus Xylopyra* (Ghont), *Schleichera trijuga* (Kusum), *Ougeinia dalbergioides and Albizza lebbek* as hosts in Bombay. He refers also to two further hosts *Xylia dolabriformis* and *Prosopis spicigera,* we have no records of these trees as hosts and they have not therefore been included in the host tree list in this book.

Sindh.

In Sindh, the host of major importance is *Acacia arabica* (Babul). Lac growing tracts are in the Jerruk Forests, near Hyderabad and on the banks of the Jamrao and Nera Canals. Swarming dates appear to be July and November. Lac is also grown in the Miani, Hala, Hanyhand and Katian Forest Ranges. The production of Hyderabad Sindh lies between 3,000 and 5,000 maunds per annum.

Hyderabad Deccan.

In Hyderabad Deccan the main host is *Butea frondosa.* Lac is grown in the Warangall, Medak, Adilabad and Karimnagar Districts. *Schleichera trijuga*

also occurs in Hyderabad. *Ficus religiosa, Ficus infectoria* and *Ficus Bengalensis* also occur but are not used to any extent as lac hosts. Swarming is said to occur twice a year, differing with the climatic conditions in various districts, the dates given are January-February and May-June, the swarming periods are recorded as being lengthy but have been calculated from the Persian months by tallying them with the English months and this may have lead to inaccuracy. Lac received from Hyderabad swarmed at Namkum in December-January, and it would appear likely that the swarming dates are December-January and May-June. The reason for these equal crops in Hyderabad, unlike those found in the rest of India, may be due to climatic conditions or to a Kusmi strain in the lac.

The output does not exceed a few hundred maunds per year; roughly 100 to 900 maunds per year.

Central India.

In Central India lac is grown in certain Native States of which Rewa is the most important. Palas is the main host. Lac is also grown in the Satni-Maihar District. In Jodhpur a strain of lac is grown on Ber of which the cells are of two colours, some being the usual crimson colour and others a bright yellow colour. This is being investigated at Namkum and an attempt is being made to isolate a pure yellow strain. Lac is grown also in Gwalior State, and in Dholpur State, Eastern Rajputana. The production of Central India may be roughly estimated at about 36,000 maunds per year. Host trees are Palas and Kusum.

Kashmir.

In Kashmir small quantities of lac are collected. The main host is *Acacia Catechu* (Khair) which grows in the Billawar Forests. Lac is also grown on *Zizyphus Jujuba* Ber.

Madras.

In the Madras Presidency lac is grown to a very small extent in Mysore, Travancore, Kanara, Trichinopoly, Bangalore, Denkanikota, Salem District, Vizagapatam, Madura, Chepuk and Kumbakonam. Hosts occurring are *Schlechera trijuga, Butea frondosa, Zizyphus Jujuba* (Elandai) and *Acacia arabica* (Karugai).

In the Denkanikota district lac is said to occur also on *Dolichos falcatus* and *Atylosia mollis.*

Of particular interest is the host tree *Shorea talura* (Jalla) on which the lac insect in Mysore is trivoltine passing through three life cycles in thirteen months instead of the usual two. This has already been referred to in Chapter I.

Pithecolobium saman the Rain Tree is utilised as a lac host in Vizagapatam. the quality of lac produced however is poor. In Denkanikota a creeper *Atylosia albicans* is utilised as a host.

Orissa. In Orissa lac is grown in the Sambalpur district and the Feudatory States of which the most important is Gangpur. Lac is also found in small quantities in the Chilka District and in Ganjam in the Kallikote district.

The occurrence of lac in the Chilka District is of particular interest as lac is said not to flourish on the sea coast. Lac was observed in this district on *Acacia Suma* (San-kanta), *Polyalthia suberosa* and on *Flemingia Congesta* Var. *Semialata.* (Marda Noyi).

The production of Sambalpur-Gangapur is estimated at between 3,000 and 6,000 maunds per annum.

Bhopal. Small quantities of lac are produced in Bhopal, in the last 3-4 years the production has been between 100 and 300 maunds. Principal hosts are *Butea frondosa, Zyzyphus Jujuba* and *Ficus sp.* at present. Both *Schleichera trijuga* and *Zizyphus Xylopyra* also occur. Swarming takes place in June-July and November-December.

Table VIII in Chapter II gives a very approximate estimate of the annual production of the more important lac growing areas in this country.

CHAPTER XVII.

LAC CULTIVATION IN ASSAM.

Kusum is unknown and there are therefore only two crops during the year, which are known as Katian corresponding to the Katki and Jethua corresponding to the Baisakhi. The former is the major crop, the latter being largely a brood crop. The dates of the two crops vary somewhat from district to district, however in general the Katian crop is May-June to October-November and the Jethua, October-November to May-June. **Crops.**

The annual production of Assam is roughly 30 to 50 thousand maunds. **Production.**

The major lac growing areas are the Rhongkhong and Duar Amla Mouza of the Mikir Hills in Nowgong, Golaghat and the Garo Hills, and the Umraon Elaka of the Khasi-Jaintia Hill Districts. **Lac growing area.**

Nowgong is the biggest area of lac production in Assam. The major portion of the lac produced is grown on *Cajanus indicus* (Arhar), *Grewia multiflora* and *Leea robusta*. Other minor and less important hosts are *Flemingia congesta, Ficus altissima, Ficus religiosa.* **Hosts.**

The method of cultivation on *Cajanus indicus* is as follows. Arhar seeds are sown in March, and the resulting plants inoculated in October-November. The following May-June, in the case of the healthiest plants, lac is broken from them by hand leaving sufficient for natural infection. Poor plants are rooted out. The next crop is reaped in October-November and a similar procedure followed. The third and last crop is taken the following May-June. **Cultivation on Arhar.**

For example:

March-April ..	1937	Arhar is sown.
Oct.-Nov. ..	1937	1,000 plants are infected.
June ..	1938	Lac broken from 300; remainder rooted out,
Oct.-Nov. ..	1938	Lac broken from 100; remainder rooted out.
June ..	1939	Crop is cut and all plants rooted out.

Arhar plants generally remain in the ground for 2 years, the period however depends on the soil, the growth of the Arhar and the intensity of the first infection. Three crops are not always taken, and in any case the second crop is generally the largest.

Lac cultivation in the Garo Hills is carried on in an area bounded to the North by the Goalpara district, Someswari to the South, the Khasia and Jaintia Hills to the East and by the Jinari river to the West. **Garo Hills.**

The method of cultivation in the Northern Garo Hills is as follows:—

Cajanus indicus (Nandu) is sown in 'jhumed' areas in May and is infected with lac the following October-November. The resulting crop matures in May-June and is utilised to infect any one of the following hosts for the Katki crop. These latter hosts are all trees.

Grewia multiflora.	Bolmengo
Ficus Rumphii	Prap
Ficus Bengalensis	Giting
Kydia calycina	Boldabak
Engelhartia spicata	Wakgru.
Albizzia lucida	Galwang.

The shrub *Leea robusta* Gangma is also used as a lac host.

C. indicus after yielding the one lac crop and its own seed is pulled out. No special pruning of the tree hosts is done, beyond the actual cutting of the lac crop.

About 1-2 chittacks of brood are used to inoculate *C. indicus* and from 4 chittacks to ½ seer are used to infect trees such as *G. laevigata.*

Mikir Hills. In the Mikir Hills the main areas of lac cultivation are the Rongkhong and Duar Amla Hill ranges.

Cultivation is carried out in a similar manner to that employed in the Garo Hills, the seasons however are somewhat earlier. *Cajanus indicus* is used in the same way as in the Garo Hills, grown in 'jhumed' areas, being utilised as a Baisakhi (Jethua) host. *Flemingia congesta* is also however used as a Baisakhi (Jethua) host in this district.

Host plants in the Katki (Katian) crop are infected with either *C. indicus* or *F. congesta* brood in April-May. The hosts used for the Katki (Katian) crop are the following, of them, all but *L. robusta,* the giant *Leea,* are trees. *L. robusta* is a shrub.

Grewia multiflora
Albizzia lucida
Ficus sps.
Leea robusta

Some ¼ to ½ chittacks of brood are used to infect *C. indicus* and yields vary from 2 chittacks to 1 seer. *L. robusta* receives about 1 seer of brood and may give a return of as much as 20 seers.

In the Khasia Hills, Birnchat, Shillong and Umraon Districts, the main hosts are four only, all of which are shrubs, except *Ficus cunia*.

Khasia Hills Birnchat, Shillong and Umraon Districts.

1. *Cajanus indicus*
2. *Flemingia congesta*
3. *Leea crispa*
4. *Ficus cunia*

C. indicus is sown in May-June at a spacing of $7' \times 7'$ and is infected the following October, the resulting crop is reaped in May when *C. indicus* is rooted out and fresh seed is sown. It is therefore a Baisakhi (Jethua) host.

F. congesta is also a Baisakhi (Jethua) host, it is planted in the early rains and is ready for infection 18 months later in October-November.

F. cunia is used for either the Baisakhi or Katki crops, (Jethua or Katian.)

Leea crispa, a shrub, is planted at the end of April when the new shoots begin to appear. Approximately 1 foot of old stem with a portion of root attached is planted. By June a new stem has appeared and is usually between 2'-3' high. Planting is usually either $10' \times 12'$ or $12' \times 12'$. It is possible to infect the plants, using *F. congesta* or *C. indicus* brood, one year after planting (i.e.), the following May. But they are better left until two years old. Plant May 1937 infect May 1939. *L. crispa* is almost always infected for the rains (i.e. Katki (Katian) crop) only. In some district it is infected 18 months from the date of planting and used as a Baisakhi (Jethua) host.

L. crispa receives some 2-3 chittacks of brood and may yield from 3 to 4 seers. It is a useful host as it seems to be almost unkillable and is even unharmed by *Termites*. The lac also is very easily broken from the twig, by taking each end of an infected twig and twisting in opposite directions when the encrustation if thick usually comes off in one piece.

Grewia laevigata is also said to be a lac host in Assam.

It is interesting to record, that Mr. R. N. De of the Forest Department, Assam observed in February in the Northern Range of the Garo Hills Division the following plants accidentally infected with lac from some neighbouring *Cajanus indicus* plants, *Shorea robusta* (Sal), 2 year old seedlings, and *Bursera serrata*. The lac on these species appears to have died without reaching maturity. This single observation does not justify these species being classed as lac hosts.

I should like to thank Mr. Adhikari of the Assam Forest Service and a late member of the Indian Lac Cess Committee for his kindness in reading through this chapter for me and for valuable criticism and advice.

CHAPTER XVIII.

LAC CULTIVATION IN BURMA.

Burma is divided into seven Forest Circles, and the Federated Shan States. States.

Lac growing area.

Lac grows in four out of the seven Forest Circles, these are the Delta, the Northern, the Central and the Chindwin, Circles. The Federated Shan States however produce 70% or more of the lac out-turn of Burma, they consist of two divisions, the Northern and the Southern.

In the Northern division lac is found in the Hsipaw and North Hsenwi States; in the Southern it is found in the following states:—Lawksawk, Maw, Yengan, Kyaukse, Yawnghwe, Mawnang, Samka, Loilong, Mongpai, Sakoi, Namtok, Wanyin, Nawngwan, Namkok, Hopong, Monhnai, Laikha.

In the Central Circle lac is found in the Maymyo division; in the Northern Circle in the Katha, Mansi and Bhamo divisions; in the Chindwin Circle in the upper Chindwin, Yaw, Minbu, Myithlha and Mu divisions; in the Delta Circle in the Thayetmyo and Henzada divisions.

Method of cultivation.

Cultivation is carried out in a very haphazard manner. The method employed is very largely to cut lac from inoculated trees and to sell it as stick lac making no provision for future crops. Trees are reinfected by lac accidentally or otherwise left while cutting, or from other infected trees in the vicinity by such agencies as wind or birds. It is believed that *Schleichera trijuga* (Gyo) should be rested from infection after every seventh crop ($3\frac{1}{2}$ years) and that *Butea frondosa* (Pauk) and *Zizyphus Jujuba* (Zi) should be rested after every third crop ($1\frac{1}{2}$ years).

In the Northern Shan States some systematic lac cultivation is carried out

Crops.

There are two lac crops during the year, Kusum and non-Kusum hosts apparently swarm at the same times. Swarming periods also are reported as being lengthy, extending over a month and even more. This may be in part due to climatic conditions but is also due to haphazard cultivation methods and the practice of permitting natural infection to occur repeatedly. It also appears that indiscriminate crossing of Kusum and non-Kusum strains probably occurs.

Swarming periods.

The swarming periods in the majority of districts in the Federated Shan States are April and September-October. The latter is the major crop and yields superior lac, the former being largely a brood crop. It will be noted that this agrees fairly closely with what is found in Assam.

In other districts the seasons are February-March to September-October.

Reports of swarming in isolated areas are occasionally given at other dates as for example, Hsipaw State, February and Hsatung State, July. These dates however may be unreliable, or male emergence may have been mistaken for swarming.

Lac is frequently cut immature, and no effort is made to differentiate between different grades, or lac from different hosts, which is all lumped together. Adulteration also occurs, sticks stones and rubbish being added to increase the quantity. Lac also is not scraped from the stick. Much could be done to improve the quality and reputation of Burma lac by remedying these abuses. **Adulteration.**

The annual production of Burma is 50,000 to 80,000 maunds. The greater part of the production of Burma is exported from Rangoon to Calcutta, where it is utilised for manufacture after mixing with Indian stick lac, usually Baisakhi. **Production.**

The principal hosts in the Federated Shan States are--

Schleichera trijuga	Gyo.	*Pentacme suavis*	Ingyin,
Butea frondosa	Pauk.		
Berrya amonilla	Petwun.		
Zizyphus Jujuba	Zi.		
Albizzia odoratissima	Taung-Magyi.		
Engelhartia spicata	Thitnu.		
Dalbergia cultrata	Yindaik.		

Host Trees.

Less important hosts are the following *Ficus* sps.

F. cunia	Thadut.	*F. infectoria*	Nyaung-gyin.
F. glomerata.	Thapan.	*F. nervosa*	Nyaung-peinne.
F. hispida	Kadut.	*F. obtusifolia*	Nyaung-gyat.
F. indica	Nyaung-thabye.	*F. religiosa*	Bawdi.
		F. Roxburghii	Sinthapan.

In Maymyo Division the principal hosts are *S. trijuga, D. cultrata, E. spicata, P. suavis,* and *Butea superba* (Pauk-nwe), together with a number of the *Ficus* sps already recorded.

In the Northern Circle lac is grown on *P. suavis, Anona squamosa* (Awza), *Dalbergia Oliveri* (Tamalan), *F. nervosa, Entada scandens,* and *Z. Jujuba.*

In the Chindwin Circle, lac is mainly grown on *P. suavis, F. indica Bursera serrata* (syn *Protium serratum*) (Thadi), *D. Oliveri, Shorea obtusa* (Thitya), *Z. Jujuba, A. squamosa, Albizzia lebbek* (Kokko), and *Pithecolobium saman* (Thinbaw Kokko).

Lac has been observed on a number of other host species in Burma. Host species of major importance only have been included in this chapter.

It is interesting to record that *Eublemma amabilis* and *Holcocera pulverea* are major lac enemies in Burma as they are in India. Cocoons of *Chrysopa sp* have also been observed in Burma lac. Of friendly species, *Microbracon greeni* parasitic on *E. amabilis,* and *Apanteles tachardiae* parasitic on *H. pulverea* are known to occur in Burma. **Insect enemies.**

It is also interesting to note that the *Cosmopterygid, Pyroderces (Antachryntis) falcatella,* Stainton, is damaging to stored lac in Burma. This species recorded from *S. talura* lac in South India and occasionally observed at Namkum is not a serious pest of stored lac in this country.

CHAPTER XIX.

INSECT ENEMIES OF LAC AND THEIR CONTROL.

The average annual production of lac in India is approximately ten lakhs of maunds (10,00,000 mds.). This does not include the production of Assam and Burma which amounts to roughly fifty to eighty thousand maunds, per annum.

Types of damage to the lac crops.

Damage to the lac crops is of two kinds:—

1. Damage due to causes other than insect enemies.

2. Damage caused by insect enemies of the lac insect.

Damage due to causes other than insects.

The former may be said to account for no less than 30%—40% of the original settlement of lac larvæ, in part it is unavoidable as the larval settlement is of such a density that if mortality did not occur there would be no room for the development of the cells; part is caused by climatic factors such as intense heat, frost, hot dry winds etc.; part is however reducible being due to faulty cultivation methods such as incorrect pruning, infection of host trees for crops to which they are not suited or with unsuitable strains of lac. Use of the information supplied in preceding chapters of this book and in the case of Kusum (*Schleichera trijuga*) in Institute Bulletins Nos. 15 and 20 also, (Simple English version and Hindi and Oriya translations are available) will help considerably in reducing this type of damage to a minimum.

The resinous secretion produced by the lac insect has for its function the protection of the insects, which are soft-bodied and unable to move after settlement, from predacious and parasitic enemies as for example, other insects, birds, etc. The insect enemies of lac have however succeeded in attacking the lac insect inspite of this protective covering.

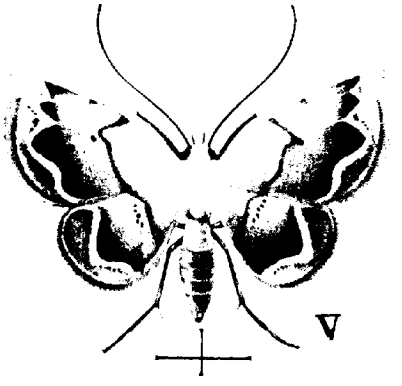
Damage by insect enemies.

The damage done by insect enemies to the lac crops is approximately 30—40% of the lac cells. The actual crop obtained is roughly one-third of the possible *hypothetical* crop, because although as few as only 10% of the cells may survive to the end of the crop, between 30—40% take an appreciable part in lac secretion, and 30% of the original settlement is male.

Parasites.

There are two groups of insect enemies which attack the lac crops, these are the parasites and the predators. The parasites are small winged insects belonging to the *Chalcidoidea* which lay their eggs into the lac cell *via* the anal tubercular opening. A grub hatches from the egg and feeds on the lac insect within its cell, these grubs do not feed on the lac encrustation. The damage done by this class of enemy has been shown to be small at Namkum, the average

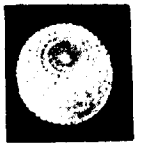
Eublemma amabilis — **The white enemy moth of lac.**
यूब्लेमा अमाबिलिस — लाह कि दुश्मन सफेद तितली
ईउब्लेमा एमाबिलिस — लाक्षा कीटेर शत्रु सादा प्रजापति
یوب لیما اَمابیلس — لاکھ کی دشمن سفید تتلی



V

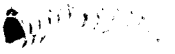
Female moth
फीमेल मॉथ
मादा तितली
स्त्री प्रजापति
مادہ تتلی

IV



I

III



II

A

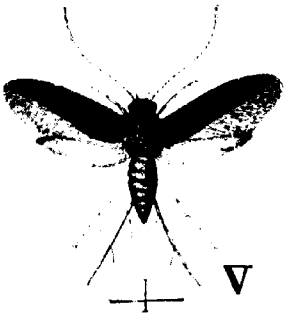
Egg
एग-अण्डा.
डिम
اِگ - اَنڈا

Larva.
लार्भा-पिल्लू-भुरला.
कीट
لاروا بھولا کیڑا

Pupa
प्युपा-पुपला
पिउपा
پیوپا

Holcocera pulverea — **The black enemy moth of lac.**
होलकोसेरा पलवेरिया — लाह की दुश्मन काली तितली
हलकोसेरा पलभेरिया — लाक्षा कीटेर शत्रु, काल प्रजापति
ھلکوسیرا پلویریا — لاکھ کی دشمن سیاہ تتلی

Female moth.
फीमेल मॉथ
मादा तितली
स्त्री प्रजापति
مادہ تتلی



V

IV

I

III

II

B

Egg.
एग-अण्डा.
डिम
اِگ - اَنڈا

Larva
लार्भा-पिल्लू-भुरला.
कीट
لاروا-بھولا-کیڑا

Pupa.
प्युपा-पुपला
पिउपा
پیوپا

COLOURED PLATE II.

EXPLANATION

A. EUBLEMMA AMABILIS, MOORE. (NOCTUIDAE).

1. Egg (greatly enlarged).
2. Larva.
3. Pupa.
4. Adult. normal resting position.
5. Adult. female, spread.

B. HOLCOCERA PULVEREA, MEYR. (BLASTOBASIDAE)

1. Egg (greatly enlarged).
2. Larva.
3. Pupa.
4. Adult moth, resting position.
5. Adult. female, spread.

percentage parasitism over seven years amounted to 4·8% while the average maximum parasitism was only 9·9% for the same period, and this of cells other than those damaged by the predators. This type of damage is not understood by the average cultivator who merely sees the lac cells dying without apparent cause.

Parasite damage to the lac crops in general is believed to be small, and money or labour need not be spent in protecting lac from parasite attack as distinct from predator attack. The Baisakhi and Katki crops are more affected than the Aghani and Jethwi, the Baisakhi is slightly more affected than the Katki and the Jethwi crop is the least affected. About one-third the cells parasitised are male.

There are eight species which occur commonly in the major lac growing areas: —

Chalcidoidea.

Encyrtidæ.

Parechthrodryinus clavicornis, Cam.
Erencyrtus dewitzi, Mahd.
Tachardiæphagus tachardiæ, How.
Tachardiæphagus tachardiæ Var *somervilli,* Mahd.

Eupelmidæ.

Eupelmus tachardiæ, How.

Aphelinidæ.

Coccophagus tschirchii, Mahd.
Marietta javensis, How.

Eulophidæ.

Tetrastichus purpureus, Cam.

Of these *P. clavicornis, E. dewitzi, T. tachardiæ, T. tachardiæ* Var *somervilli,* and *C. tschirchii* are, as far as is known, solely lac parasites.

E. tachardiæ, T. purpureus and *M. javensis* occur as primary parasites, the latter very largely as a parasite of male lac insects. They occur also as hyperparasites of primary lac parasites. This function will be further discussed under the heading Biological Control. *Eupelmus tachardiæ* is further a lac enemy in that it occurs also as a hyperparasite of the two lac friends, *Microbracon greeni* and *Apanteles tachardiæ,* the former parasitic on the larvæ of *E. amabilis* and the latter on the larvæ of *H. pulverea* both of which are serious lac enemies.

Mahdihassan (1934 and 1935) has claimed that *E. tachardiæ* is parasitic on *Eublemma amabilis,* and disputed the statement that it is a lac parasite

and a hyperparasite of *Microbracon greeni*. He bases his claim on a *single* observation.

At Namkum *E. tachardiæ* has been bred repeatedly from lac cells, in which it has been found parasitic. *E. tachardiæ* also oviposits readily in the laboratory, on *Microbracon greeni* larvæ in cocoons, and has been bred from them frequently both from eggs laid in the laboratory and eggs and larvæ observed in lac samples.

In spite of the examination of many thousands of *E. amabilis* larvæ and many miles of lac encrustation during the last 10 years at this Institute no single instance of *E. tachardiæ* parasitic on *E. amabilis* has been observed.

Alternative hosts of lac parasites.

In certain cases these insects parasitise insects other than the lac insect. These other insects are termed alternative hosts which can act as alternative breeding grounds, and maintain the parasite at a high level in spite of seasons when lac cultivation is reduced or even suspended, and act as host for these enemy insects when the lac is still too immature to support them. Destruction of such alternative hosts should be carried out wherever possible.

Eupelmus tachardiæ has an alternative host in the *Cercopid, Machærota planitiæ*, Dist. a pest of *Zizyphus Jujuba* (Ber). *Marietta javensis* occurs as a hyperparasite of primary parasites of *Aspidiotus orientalis*, Newst; and *Tetrastichus purpureus* has been discovered as both a primary and secondary parasite of *A. orientalis*. *A. orientalis* is a *Coccid* pest of a number of lac hosts, and is mentioned in the chapter on insect enemies of lac host trees.

Predators.

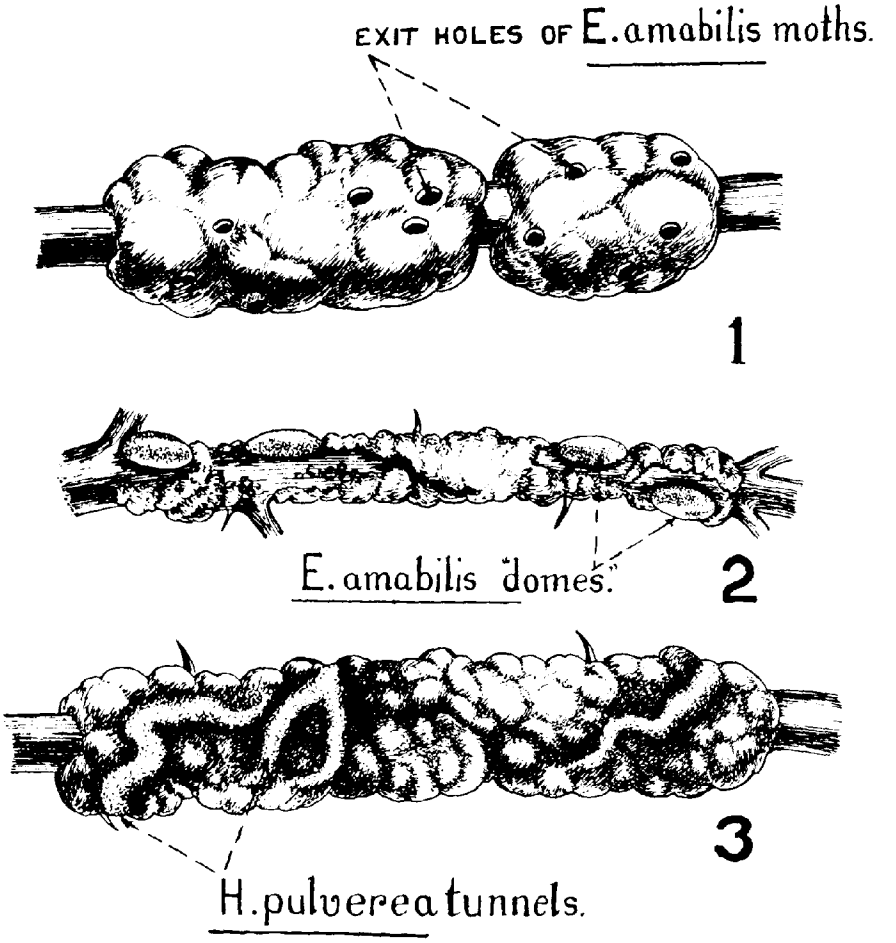
Predator damage is far more serious. Predators are insects which lay their eggs on or near the lac encrustation, the larva which hatches from the egg feeds on the lac insects, it may continue to feed from the surface or it may eat its way into the encrustation until it comes to lie entirely concealed inside. The egg is however laid outside the lac cell and the larva never inhabits one single lac cell. Pupation occurs and the adult finally emerges to repeat the cycle.

Predators of major importance.

There are two major predator enemies of lac:—

1. *Eublemma amabilis*, Moore. (*Noctuidæ*).
2. *Holcocera pulverea*, Meyr. (*Blastobasidæ*).

These two are responsible for practically the whole of the predator damage amounting to about 35% of the lac cells. Estimates of damage include all cells whether male or female. The life history of both predators is similar. The female moth lays her eggs on or near the lac encrusted branches, a larva hatches from the egg and bites its way into the lac encrustation, inside which it spends the whole of the larval life feeding on the lac insects and also on the lac encrustation. The larvæ as they feed, form a tunnel or gallery lined with silk,



TEXT FIGURE VIII.

Diagramatic figure showing lac damaged by Predators.

1. Mature Kusum lac showing exit holes of E. amabilis moths.
2. Immature Ber lac showing E. amabilis 'domes'.
3. Mature Ber lac showing H. pulverea tunnels.

excreta and pieces of the encrustation, they pupate in this gallery, and the adult finally emerges to repeat the cycle.

The larvæ of *E. amabilis* are of a dirty yellowish white colour, while those of *H. pulverea* are chocolate black, they are in addition much more active than those of the former predator. The fully coloured pupa of *E. amabilis* is a deep yellow brown, that of *H. pulverea* is smaller and very dark brown.

Both predators do more damage to the Katki and Aghani crops than to the Baisakhi and Jethwi.

Both species are cosmopolitan. Lac samples have been examined at this Institute from all lac growing districts, and not a single sample has been free from the attack of these species. *E. amabilis* attack has been observed also in lac from Burma, Indo-China and Malaya, and in samples of *Laccifer javanus* from Java.

E. amabilis is the more serious enemy of the two, it does more damage to lac in the field than does *H. pulverea*, the latter predator is however more destructive to stored lac.

Other minor predators are:—

Minor predators.

1. *Ephestia sp.* (*Pyralidæ*).
2. *Eublemma scitula*, Rambr. (*Noctuidæ*).
3. *Chrysopa sp.* (*Chrysopidæ*).
4. *Pyroderces falcatella*, Stainton. (*Cosmopterygidæ*).

Ephestia sp. occurs as a scavenger feeding on dead *L. lacca* and damaging the resin in stored lac although it is occasionally found in fresh lac also. The larvæ of this species occasionally attack and kill the larvæ of *E. amabilis* if they meet them but *Ephestia sp.* cannot be considered beneficial on this account.

Eublemma scitula is not a lac predator of importance in the major lac-growing areas, where it is rarely found attacking lac. *E. scitula* is on the whole an extremely beneficial insect on account of its larval habit of feeding on injurious *Coccids* (ex: *Lecanium longulum*, Dougl.). In Southern and Western India however where a small amount of lac is cultivated it has been reported as a serious lac enemy. The larva after hatching from the egg enters the lac encrustation and feeds within, after the second instar the larva emerges and encases itself in a dome shaped 'shell' of silk and pieces of encrustation and feeds on the insects as it crawls over them. Pupation occurs within this shell, after a silken floor has been spun, which is broken through by the emerging adult.

Chrysopa sp. The eggs are laid singly on long stalks on or near the encrustation. The larva on hatching, crawls over the encrustation, and feeds on

the lac insects by inserting its longish mandibles and maxillæ into the lac cells *via* the anal tubercular pores. The larva conceals itself by covering its back with pieces of rubbish bits of leaves and white filaments from the lac cells which are held in place by hooked hairs. Pupation is in a small circular white cocoon. This species is not often found attacking lac and the damage is small.

Pyroderces falcatella. The larvæ of this species are at times found feeding in stored lac, the larvæ are sometimes found in lac in the field and do attack living insects, though rarely. The greater part of the damage occurs due to their feeding on dead insects and resin in stored lac. This species however does not ocur to any great extent in stored lac in the major lac-growing areas. *P. falcatella* occurs in South India, and appears to be a pest of some importance of stored lac in Burma. In this connection see Chapter VIII and XVIII.

Control of insect enemies of lac.

Control.

There are two main types of control available for use against insect enemies. These are artificial control, and natural or biological control. At the present time the former is of greater importance in the lac industry, though it is hoped that the latter will soon assume supreme importance as result of the researches at present being carried out at this Institute.

A. *Artificial Control.*

Artificial Control.

The object of the next few pages is to explain in easy terms simple methods of reducing this insect damage. By far the greater part of the lac grown in India, is grown by raiyats of little education and scanty means, in small holdings over a very vast area (Chota Nagpur which produces 50% of the outturn of lac in India covers an area of over 27,000 square miles). Control measures for the raiyats use, must therefore be extremely simple and above all must require no financial outlay. Only methods of this type are described here.

The following simple controls are recommended to all cultivators, all are easy to carry out and do not necessitate any expense. Their great importance lies in the fact that they are effective against both groups of enemies Parasites and Predators.

Controls.

1. Lac intended for use as Brood should be cut as near to the time of swarming as possible, never more than 1 week before, for optimum results. The practice of cutting lac for brood, several weeks to a month before swarming is due, by cutting off the female insect from her food supply, results in devitalised brood and should be abandoned. (Negi (1933.) with Simple English version and Hindi, Oriya and Bengali translations explains how to forecast swarming dates). This control aims at the production of healthy brood and a healthy swarm.

2. IN CHOOSING LAC FOR USE AS BROOD, HEALTHY LAC SHOWING THE MINIMUM OF PARASITE AND PREDATOR ATTACK SHOULD BE SELECTED, insect enemy affected sticks should be rejected. This control has for its object the reduction to a minimum of the emergence of insect enemies from lac in use as brood. (For methods of recognition of healthy brood lac c.f. Chapter VII page 47).

3. The maximum swarming period for an individual Baisakhi female is 11 days, the average 6 days, for Katki females 16 days is the maximum and 7 days the average swarming period. The February (Aghani) periods are similar to the Katki. Swarming is at a maximum between the 1st and 5th days of the swarming period ; swarming does not start simultaneously from all cells ; in 2 weeks however the greater part of the emergence has occurred from all cells, and after 3 weeks emergence has usually ceased. Thus after 2-3 weeks the brood is no longer of any value as brood.

Although emergence of parasites and predators occurs from the lac crops while they are on the trees, by far the heaviest emergence occurs at and during the first 2-6 weeks after cutting the crop in the case of parasites, and shortly after cutting and during the first and second month after, in the case of predators. In the Katki crop after cutting in October-November, some of the predators emerge, others hibernate in the cut lac to emerge in February-March and to some extent in the intervening months. Therefore once the emergence period of the lac larvæ is over, the brood is of no value as such, and is in fact harmful as it acts as a breeding and distributing centre for insect pests.

(*a*) LAC TIED TO THE TREES AS BROOD SHOULD BE REMOVED AFTER A MAXIMUM PERIOD OF 3 WEEKS FROM THE DATE SWARMING BEGAN, if the trees are sufficiently covered with larvæ it should be removed earlier. Two weeks is generally ample for infection of host trees.

(*b*) NATURAL INFECTION (LEAVING A CERTAIN AMOUNT OF LAC (CHEENTY) ON THE TREE UNCUT TO SWARM IN SITU) SHOULD BE ABANDONED PARTICULARLY IN OCTOBER-NOVEMBER Exceptions to this rule may be necessitated, by climatic conditions, an example being natural infection of Palas (*Butea frondosa*) in hot and arid districts, or by other factors such as shortage of labour in June-July when the raiyat is planting his own food crops prior to the monsoon which may compel natural infection at this season.

4. Lac cropped from the trees is frequently stored prior to sale in the vicinity of trees infected for the new crop, or in districts where both Rangeeni and Kusmi crops are grown, of trees infected for the simultaneous crop. Parasite enemies, as has already been stated, continue to emerge for 2-6 weeks after the crop is cut, and predators for 1-2 months. From the Katki crop, cut in October-November, predator enemies hibernate in the stored lac to emerge in February-March and to some extent in the intervening months. These

enemies on emerging from stored lac in lac growing districts infect the new or simultaneous crops.

ALL LAC CUT FROM THE TREE AND NOT REQUIRED FOR BROOD AND ALL BROOD LAC AFTER USE SHOULD BE SCRAPED FROM THE STICK AT ONCE. (Lac not required for brood may be cut shortly before swarming is due). This action alone destroys many of the larvæ and pupæ of the parasites and predators, and exposes others to climatic factors and to attack by ants.

As lac is, in general, sold scraped from the stick, all this control implies is immediate scraping instead of scraping after some delay. While scraping, larvæ and pupæ of *E. amabilis* and *H. pulverea* which are observed may be killed by crushing or by dropping them into hot water. While scraping any small white cocoons should not be harmed as these are constructed by friendly insects parasitic on the larvæ of the predators.

THE SCRAPED LAC SHOULD ALSO BE REMOVED WHERE POSSIBLE FROM THE VICINITY OF LAC INFECTED TREES. The control outlined in this paragraph is particularly important in the case of Katki lac.

5. THE STORAGE OF LAC LEADS TO A FALLING OFF IN QUALITY AND YIELD ON MANUFACTURE. THE IDEAL TREATMENT OF LAC IS ITS SALE AS SOON AS POSSIBLE AFTER CUTTING TO THE MANUFACTURER FOR IMMEDIATE WASHING AND CONVERSION INTO SEED LAC (SAF CHOWRIE). THIS SATISFACTORILY ELIMINATES THE PARASITIES AND PREDATORS IN THE LAC WHICH, AS HAS BEEN STATED, WOULD EMERGE IN DUE COURSE TO INFECT THE NEW CROP WITH PEST. THE SEED LAC SHOULD THEN EITHER BE EXPORTED AS SUCH IMMEDIATELY OR BE CONVERTED INTO SHELLAC AND SHIPPED IMMEDIATELY TO A COOL CLIMATE.

This control serves the double purpose of reducing the prevalence of insect enemies and ensuring good quality and a good yield on manufacture (See also 'Some information and advice to shellac manufacturers', published by this Institute).

As has been stated *E. amabilis* and *H. pulverea* feed not only on the lac insects but also on the resin (encrustation) and thus there is in addition a loss during storage from this source. Other insects of less importance also feed in some cases on stored lac, among these are *Pyroderces falcatella* and *Ephestia sp.* Early conversion into seed lac would prevent this damage to lac during storage. See also Chapter VIII in this connection.

6. Kusum (*Schleichera trijuga*) brood should be avoided for the inoculation of trees other than Kusum and Khair (*Acacia Catechu*) in July for the Aghani (Kusmi) crop in regions where the principal crops are Rangeeni (Katki and Baisakhi). The Aghani crop matures in February, 3-4 months later than Katki, during this time it becomes further infected with insect enemies, these enemies emerge in February-March and attack the Baisakhi crop which up till

PLATE XII.

Scraping *Zizyphus*

Jujuba (Ber) Lac. Namkum, Bihar

then is not heavily pest infected, but has by then reached a stage at which it is prone to insect attack.

The adoption of these simple methods of control by *all* cultivators would very greatly reduce the damage done by the insect enemies of lac and hence benefit the raiyat by decreasing the costs of production and by increasing the yield and above all the quality of the lac obtained. An increased yield would benefit the land owner by raising the value of his trees. The reduction of pest in the crop would benefit the manufacturer in that the lac purchased by him would be cleaner and of higher quality as it would contain fewer predator larvæ and pupæ and their frass.

This combined with the fact that the lac would give a better yield on washing as it would contain fewer tunnels bored by the predator larvæ, would also tend to decrease manufacturing costs.

B. *Biological Control.*

Biological Control.

Biological Control is based on the fact that the majority of injurious insects are attacked in nature in their turn by insect enemies, which are therefore beneficial. These beneficial species may be either parasites or predators, and one or several may attack an injurious insect. A beneficial species may be monophagus (specific) in which case it attacks only one species of host or it may be polyphagus in which case several species of host may be utilised. A number of interacting factors control the extent of the damage done by insect enemies of lac, of these, two are of major importance: firstly, environmental factors which include climatic conditions and the density of the lac population *i.e.* the amount of lac being cultivated ; and secondly natural enemies of insect enemies of lac. Between the lac insect and its insect enemies an equilibrium exists determined by these factors, the average damage remains at a fairly steady level, the actual damage at a particular time varies or oscillates considerably. Beneficial species may maintain such an equilibrium at a level at which no economic damage occurs or they may only be able to maintain it at a level that, while economic damage is serious (to a varying degree) the injurious species is prevented from increasing at the expense of its host. In the Lac Industry the latter is the case. Biological control aims at preventing fluctuations in the extent of the damage and at reducing the level of the equilibrium to one at which economic damage does not occur.

Biological Control of lac parasites.

Control of lac parasites by their own natural enemies, hyperparasites, has been found to be impracticable. The following hyperparasites occur.

1. *Tetrastichus purpureus*, Cam. (*Eulophidæ*).
2. *Eupelmus tachardiæ*, How. (*Eupelmidæ*).
3. *Marietta javensis*, How. (*Aphelinidæ*).

Research in the Entomological Department has shown that hyperparasitism is low. The percentage hyperparasitism calculated over a period of five years averaged 3·6% and the average maximum was only 10·1%. The species concerned also are in each case primarily parasites of the lac insect and therefore to be discouraged.

The impracticability of natural control of lac parasites is not a serious bar to the success of natural control as the damage done by parasites has already been shown to be only very small.

Biological Control of lac predators.

Biological control of lac predators amounts in fact to control of *E. amabilis* and *H. pulverea*. A thorough investigation of these predators has revealed the following parasite species.

CHALCIDOIDEA.

Chalcididæ.

Brachymeria tachardiæ, Cam. endo-parasitic on the pupæ of *E. amabilis* and *H. pulverea*.

Elasmidæ.

Elasmus claripennis, Cam. ecto-parasitic on the larva of *E. amabilis*.

Elasmus albimaculatus, Gahr. ecto-parasitic on the larva of *H. pulverea* (very rare).

Eurytomidæ.

Eurytoma palidiscapus, Cam. endo-parasitic on the pupa of *H. pulverea*.

BRACONIDÆ.

Microbracon hebetor, Say. ecto-parasitic on the larvæ of *E. amabilis*, *H. pulverea* and *E. scitula*.

Microbracon greeni, Ashm. ecto-parasitic on the larva of *E. amabilis*.

Aphrastobracon flavipennis, Ashm. ecto-parasitic on the larvæ of *E. amabilis* and *E. scitula*.

Apanteles tachardiæ, Gam. endo-parasitic on the larva of *H. pulverea*.

Apanteles fakrulhajiæ, Mahd. suspected endo-parasite of the larva of *H. pulverea*.

Chelonella sp. (probably sp. nov.) host unknown, suspected *H. pulverea*.

ICHNEUMONIDÆ.

Pristomerus testaceicollis, Cam. endo-parasitic on the larva of *H. pulverea* (considered by Ferrière as possibly a local race of the European species, *P. vulnerator* Panz.)

VESPOIDEA.

Bethylidæ.

Perisierola sp. (probably sp. nov.) ecto-parasitic on the larva of *H. pulverea.*

All these species are indigenous except *Microbracon hebetor,* Say. Of the indigenous species the more important are *Microbracon greeni, Apanteles tachardiæ* and *Pristomerus testaceicollis. Microbracon greeni* is showing great promise as a controlling agent against *E. amabilis* and results indicate that the release of laboratory bred adults at critical times would be attended by greatly increased control.

Microbracon hebetor is not a native of the lac growing areas, although it has been recorded from South India. It was introduced in small numbers from Ceylon and from those introduced adults a small colony has been started at Namkum. Its main host in Ceylon is *Ephestia kühniella* a pest of stored products. At Namkum *M. hebetor* has been acclimatised to *H. pulverea* and *E. amabilis* as hosts and is breeding on them very satisfactorily. Other hosts of this species are all pests, many of which occur in India and are of commercial importance, they include *Platydera gossypiella* the pink boll worm of cotton. The indications are that this species will be of the greatest importance in the control of *E. amabilis* and *H. pulverea.*

Laboratory bred adults have already been released in plantations under the Institute charge under controlled conditions, and colonisation has been proved to have occurred.

Microbracon hebetor has been bred at Namkum also on *Hieromantis ioxysta, Meyr. (Schreckenstineidœ)* a leaf roller pest of *Schleichera trijuga* (Kusum), and on *Tonica niviferana* a borer on *Bombax malabricum* (Simul).

The *Braconid, Cedria paradoxa,* a number of cocoons of which were sent to Namkum from the Forest Research Institute, has been found to oviposit on *Eublemma amabilis* at Namkum under laboratory conditions, adults were successfully bred from these eggs with *E. amabilis* as host. Eggs were also laid on *H. pulverea,* but adults were not bred, as the larvæ died shortly after hatching.

At this point it should be made clear that, although results show that satisfactory biological control is definitely within the bounds of possibility, artificial controls are *at present* of major importance. The simple controls recommended in the early part of this chapter should be thoroughly and widely utilised by all classes of cultivators.

Other insects associated with lac.

Other insects associated with lac.

Various insects other than definite lac enemies are found associated with lac, of these the more important are the *Formicidæ* or ants. Ants in general have been found not to be injurious to lac. They visit the lac encrusted

branches to obtain the 'honey dew' secreted by the lac insects and are useful in this respect as they remove this secretion which at times may become mixed with dust and block the brachial pores or breathing holes of the lac tests and cause the insects inside to die of suffocation. Certain species are beneficial in that they attack the larvæ of *E. amabilis* and *H. pulverea* when they gain access to them either as they hatch from the egg or when they find a hole in the encrustation through which they can obtain them; the value of this is *not* great as the larvæ of the predators enter the encrustation immediately they hatch from the egg and spend their whole life inside it, invisible from the exterior and are thus not available to the ants. Examples of ants which prey upon predator larvæ are *Camponotus compressus* and *Solenopsis geminata rufa; Iridiomyrmex anceps* may also attack predator larvæ especially if the larvæ happen to be injured.

Formicidæ (Ants).

Lac grown on trees visited by ants is often found to have none or only short white filaments, as they are broken off by the ants walking over the encrustation. This is not harmful as is supposed by some cultivators; the white filaments are not part of the tracheal respiratory (breathing) system and are developed primarily to ensure that the respiratory and anal holes are not blocked during lac secretion.

Certain ants are harmful at the times of swarming and to a minor extent at male emergence, in that they may attack and kill lac larvæ and male lac insects. Among species which may behave in this way are *Meranoplus bicolor* Guer. *Solenopsis geminata rufa,* Jer. *Cremastogaster dohrni,* Mayr. and *Iridiomyrmex anceps,* Roger.

Where these enemy ants occur and are found to be doing harm quite simple controls may be used. One of the following will be found satisfactory: —

1. Bands of gum may be pasted round the trunks of the infected trees; they tend however to loose their stickyness and hence the power of catching ants.

A proprietary Grease Banding material supplied for test by Messrs. The Imperial Chemical Industries, Calcutta, was found to be effective in preventing the access of *Solenopsis geminata rufa,* but failed to prevent the large black ant, *Camponotus compressus.*

2. Cheap molasses may be pasted round the trunks of the trees or spread on grasses and tied round them.

3. A counter attraction bait of crushed sugar cane or honey comb from which the honey has been extracted, or other sweet substances may be strewed on the ground, and will be found a much greater attraction for the ants, than is the lac insect.

Should ants be found in any district and be proved to be definitely harmful to the lac insects and the encrustation, these controls may be applied and their nests (*Formicaries*) destroyed by pouring hot 10% Phenyle into them wherever found. Alternatively the *Formicaries* can be fumigated (cf. Chapter XXI Fumigation of *Termitaria*).

Reports of ants damaging lac are sometimes received at this Institute. Such reports have not usually been confirmed by the evidence. It seems probably that they owe their origin to cultivators, seeing ants swarming over the lac, imagining them to be attacking it, and to the fact that lac infested with ants is usually devoid of white filaments.

Other ants frequently found associated with lac are the following:—

Camponotus near *varians,* Roger.

Camponotus mitis, Smith.

Monomorium near *indicum,* Smith.

Cremastogaster subnuda, Mayr.

Sima near *alaborans,* Walker.

Solenopsis geminata, Fabr.

Tapinoma melanocephalum, Mayr.

Another ant frequently found on lac inoculated trees is the common red tree ant *Oecophylla smaragdina.* This species builds its nest in the trees and has a painful bite. It is often found on Kusum trees. Where trees are heavily infested, coolies will often refuse to climb them for pruning, infection or crop reaping. In these cases the nests should be destroyed by cutting them down and either burning them or keeping them under water for some time. There have been reports also of this species damaging lac, but they have not been confirmed, and are probably mistaken.

Coleoptera (Beetles).

Another important group associated with lac is the *Coleoptera* or Beetles. These insects appear to be harmless scavengers feeding on rubbish and bodies of dead insects. Certain species however probably do as small amount of damage to stored lac. The following species are commonly bred from lac.

1. *Silvanopsis iyeri,* Grouv.
2. *Tribolium castaneum,* Hbst.
3. *Berginus maindroni,* Gr.
4. *Cathartus advena,* Walt.

Thysanoptera and Psocoptera.

Two other groups of insects are commonly found associated with lac, these the *Thysanoptera* or *Thrips,* and the *Psocoptera,* a group of insects which

includes the book lice and their allies. In either case these associates are to be considered as harmless, as they act entirely as scavengers.

APPENDIX TO CHAPTER XIX.

The following *Encyrtids* are recorded by Ferrière (1935) as having been received by him from Bangalore bred from lac, their host is unknown except in the case of *A. hautefeuilli,* Mahd. which is a parasite of lac

Atropates hautefeuilli, Mahd.

Anicetus dodonia, sp. nov.

Prolearocerus fulgoridis, sp. nov.

These species have not so far been recorded from lac at Namkum.

Ferrière (ibid) has also recorded the following parasites of lac predators, these have not been observed at Namkum.

Parasitic on *Holcocera pulverea* Meyr. the *Braconids, Phanerotoma, buchneri,* Fabr, and *Agathis bischoffi,* Fabr.

He has further recorded the following species from lac, host unknown. It would appear however that they are probably parasitic on insects predatory on lac.

Ichneumonidæ.

1. *Pristomerus laccæ,* Cushm.

Braconidæ.

1. *Holobracon coxalis,* Turner.
2. *Blacus tachardiæ,* Cam.

The *Cecidomyid, Dentifibula lacciferi,* Barnes. is reported by Miller (1937) as a lac predator in Malaya. This species was bred at Namkum from a sample of lac believed to be *Laccifer javanus,* Chamb. from Java. It does not appear to occur in India.

A single *Cecidomyid* was bred from each Ber x Khair lac Namkum and Palas x Palas lac Mako; Latehar. They have not yet been determined. They emerged from the parasite cages and their function is not known.

CHAPTER XX.

ENEMIES OF LAC OTHER THAN INSECTS.

Although insects are the major enemies of the lac cultivator there are a number of enemies other than insects which occur.

Theft.

Of these the worst and most troublesome is the thief. Theft of lac from infected trees presents very little difficulty, it can be done under cover of darkness, and when lac has once been cut it is almost impossible to prove from which trees it was cut. Thus unless the culprit is caught red handed in the act, it is very difficult to bring the crime home to him and he usually escapes scot tree.

Influence of theft on of Lac Cultivation.

Theft is responsible for a number of facts and practices in lac cultivation. Of these the most serious is the necessity for Chowkidars or guards to watch the trees, and to whom payment must be made. The cost of such watching absorbs much of the profit from cultivation and is largely responsible for the scarcity of cultivators of the private individual class. Naturally, theft does not affect the raiyat cultivator to anything like the same extent, and again chowkidaring of the trees does not cost the raiyat anything, being family labour. Theft naturally is a very serious matter in lac plantations, and considerable sums of money have to be spent in preventing it. It is also responsible for the fact that a large number of perfectly healthy infectable lac hosts are left uninfected annually, these being trees which are isolated, or are situated far away from villages and therefore difficult to guard.

Premature cutting

The fear of theft is in part also responsible for premature cutting. as has already been stated does not occur to any great extent in Katki and Jethwi crops, the reason being that these crops are particularly important as brood crops for the principle commercial crops, the Baisakhi and Aghani.

It has been explained that the partial cutting of the Baisakhi crop in April-May, is not harmful as by this time the greater part of lac secretion has already occurred. Also that this practice is valuable in that it relieves the tree of the drain made on it by the insects feeding on the sap, and also acts as a pruning. This custom also serves to reduce chowkidari costs as only lac required as brood is left on the trees, all not required for this purpose is cut. This means in practice that many trees are completely cropped and only such trees as have been left uncut to carry brood lac, need be guarded against theft.

The Aghani crop like the Baisakhi is an important commercial crop. During the early stages of this, or for that matter, any crop, stealing is not likely to occur, the lac being too immature. In the Aghani crop stealing is not really to be feared before about November. It is about this time, Aghan, November-December that cutting of the Aghani crop begins, as has been stated elsewhere, part of the reason for this practice is fear of theft. This premature cutting is wasteful as in the Aghani crop, unlike the Baisakhi, secretion continues up to shortly before swarming is due to occur.

It is difficult to suggest any methods of stamping out theft, but it is suggested that where offenders are caught that the punishment should be severe. The necessity of guarding the lac however remains. The fear of theft *is not however so great as it was, as the present low price of lac is not a very* great inducement to steal.

Other enemies. Other occasional enemies of the cultivator are birds, monkeys, squirrels and rats. The sporadic visits of these animals to lac infected trees served their purpose to wild growing lac in days gone by, in that the larvæ were accidentally transferred by them from one tree to another. To the cultivator they may however be detrimental.

Monkeys. Monkeys are damaging mainly from mischievousness, pulling down the sticks of brood lac tied to the trees, breaking the lac from the twigs etc. They are seldom serious enemies of the cultivator as very little lac is grown under jungle conditions, where monkeys are likely to occur. Some form of scare, worked by the wind, might be used if monkeys are found to be troublesome.

Squirrels. In some districts squirrels break off the encrustation with their teeth, where this occurs, the heaping of thorn covered branches, such as the prunings from Khair or better Babul, round the trunks of the trees may be tried to prevent their access to the trunk.

Rats. Rats are occasionally reported as damaging lac, by biting the encrustation with their teeth. This damage however is most liable, on infected trees in the immediate neighbourhood of villages. The only control possible is the extermination of the rats by the usual methods, such as traps. However probably the best way of dealing with rats is by natural control in the form of cats.

Birds. Birds occasionally damage newly settled larvæ with their claws in alighting on recently infected twigs. This damage may be said to be practically negligible, and birds in general are not to be considered as lac enemies.

Wood-peckers. Recent reports and observations have shown however that certain species of woodpeckers are harmful to lac. They peck off large pieces of the encrusta-

tion apparently in search of the larvæ of *E. amabilis* and *H. pulverea* feeding below. This observation is only recent, (end of 1936) and few details have been worked out so far, nor has it been possible to shoot or trap any of the offenders for examination and identification yet. Their habit of feeding on predator larvæ is of course beneficial but is out weighed by the large amount of lac that is broken from the twigs during their search. They have only been observed damaging Kusum x Khair lac, and it is possible that this damage is largely due to the fact that Kusum x Khair lac is rather brittle when nearly mature and is easily broken from the twig. There have been no reports of woodpeckers attacking Palas or Ber lac, nor have they been observed pecking Kusum lac. It seems very unlikely that they would do much harm to lacs other than Kusum x Khair which are less brittle and would not break away *from the twigs as result of pecking. This matter is however receiving attention* at this Institute.

Lizards.

Circumstantial evidence from Ceylon suggests that lizards may at times damage lac. The lizards were not identified nor were they actually observed damaging lac, they were however observed on trees where many of the lac cells had been broken open. I owe this piece of information to Mr. Hutson Government Entomologist, Ceylon.

CHAPTER XXI.

INSECT ENEMIES OF LAC HOST TREES.

General. It must be understood that insects which damage lac host trees are also enemies of the Lac Cultivator, in that they lower the vitality of the tree and hence its ability to sustain the lac insect. Such insect pests are serious enemies in lac plantations where they retard the growth of the trees, thereby lengthening the time which must elapse between their planting and their attaining sufficient growth to be able to stand a lac infection. In certain cases insect pests may even kill the trees attacked.

Host tree pests may be roughly classified into three groups.

1. Biting insects.
2. Sucking insects.
3. Boring insects.

1. *Biting Insects.*

White ants. The most serious of the biting insects are the *Termites* or white ants. In Nurseries they attack young seedlings and plants, biting through the stems just below the surface of the soil. On trees they build covered earth tunnels up the trunk, under which they attack the bark and do considerable damage, not the least of which is that this removing of the bark and attack on the tree, provides an excellent place of attack for other enemies. Further, on infected trees their earthen tunnels may extend over the lac encrusted branches. In these cases the lac below may be attacked, but in any case dies due to blocking of the essential pores. Lac cut from the trees should never be left lying on the ground as if this is done *Termites* will most probably attack it.

The earth tunnels should always be scraped from tree trunks as soon as they are observed, white ants do not care for the light and the removal of their tunnels allows other insects to attack them.

Foot wide bands of the following composition may be painted round the trunks of valuable or lac infected trees.

Quick lime	... 2 parts.
Paris Green or lead arsenate paste ...	... 1 part.

The Quick lime should be slaked in as little water as possible.

Natural enemies of white ants. The most important natural enemies of *Termites* are Ants. Two species particularly feed on *Termites* to a large extent, these are *Lobopelta sp.* and *Solenopsis geminata rufa,* Jerd. The former has an extremely painful bite, the latter a somewhat unpleasant sting.

PLATE XIII.
Fumigating a White Ant Termitarium,
Namkum, Bihar

The following control was suggested in the first edition of this Manual.

S. geminata rufa may be used as a control against *Termites*. In Nursery beds and other places where *Termites* are found, the soil at the surface should be turned over to the depth of about 1-2 inches, this should be done every now and then after the seeds have germinated. A nest of red ants should then be found and a kerosene tin of the loose earth which is well mixed with ants can be brought from the nest and spread over the Nursery beds. The red ants will not harm the seedlings and will rapidly seek out and kill the white ants, they may possibly remove a few of the seeds, but this treatment is not suggested until the seeds have germinated and are safe from this form of attack.

Solenopsis germinata rufa is very common in this district, the ant is a fairly dark reddish yellow colour and 2·5—3 mms. in length. The surface of the nest is characterised by a roughly oval patch of fine sand, which may in a fresh nest show small round entrance holes at the bottom of slight depressions. The nests are commonly found either on flat ground or in the sides of bunds.

This method of attack is still to be recommended, later work however has shown that *S. germinata rufa* is at times harmful itself, in that it attacks some garden plants (*e.g.* Dahlias) and a number of types of vegetable including potatoes, usually by biting into and finally through the green stems. Thus the use of red ants in control of *Termites* is to be avoided in gardens and in vegetable growing districts, or in the immediate vicinity of villages.

Artificial control of white ants.

Phenyle 10% may be sprinkled round the trunks of trees attacked by *Termites*. Digging out the nest and destroying the Queen is seldom effective as it is rarely that anything like all the *Termite* individuals are killed, and there are in the nest a number of individuals which can take upon themselves the functions of Queen under these circumstances. Heavy dosing with 10% phenyle makes digging out more effective.

However the most satisfactory method of dealing with *Termites* whose *Termitaria* are visible, is by fumigation.

There are on the market some excellent machines which destroy the nests by fumigating them. The principle is as follows: air from a hand-pump is blown over the surface of a small brazier containing burning charcoal. On the charcoal is sprinkled a powder which produces poisonous fumes, these are led down a flexible tube ending in a nozzle. The method of working, is to insert this tube into a hole in the nest and vigorously to pump the poisonous fumes into it, as the fumes are seen to come out of other holes in the nest these are blocked up. Finally the tube is withdrawn and this hole blocked up. The nest can then be opened after three days, when all the *Termites* are found to be dead. These machines are extremely efficient and very well worth the money, and are cheap and easy to use.

Good results have been obtained at Namkum with the Blue Mysto White Ant Exterminating Machine, which works on this principle the cost of the machine is Rs. 63/- and the powder, which gives rise to arsenous sulphide, costs 1/8/- per lb. tin, imported by the General Export Co., 55-58, Ezra Street, Calcutta.

Preliminary experiments with Cynogas, a proprietory product marketed by The Imperial Chemical Industries, using a hand blower did not give very satisfactory results. This product is being further tested at Namkum.

Where a fumigating machine is not available one of the following methods may be utilised:—

Paris Green used as a powder mixed with sand, may be dusted into the cavities of the nest; Sodium or potassium cyanide may be poured in as a 3% solution in water.

The nest may be opened at one place and small doses of one of the following fumigants poured in, after which the opening is covered in with soil and left.

1 part	...	... Creosote.
3 parts	...	... Kerosene or Petrol.

Petrol alone used at Namkum in this way was found to be *very* satisfactory.

Other fumigants are carbon disulphide, which it should be remembered is not only poisonous but also highly inflammable, and paradichlorbenzene which is safer to use but rather less effective.

In Nursery beds where young plants are found to be dying off, the soil should be systematically turned over. This alone is a valuable control as it exposes the white ants to attack from their natural enemies, and also tends to drive them away. Napthalene or paradichlorbenzine chrystals may also be mixed with soil and will be found a useful repellent.

Much valuable advice will be found in "Control Measures for *Termites*" by C. F. C. Beeson (1934.)

Karanj cake used as a manure is valuable in that it is repellent to *Termites*.

Phenyle should never be allowed to come into direct contact with young plants.

The majority of the host tree pests are sporadic, which means that they do not constantly occur as pests, but that outbreaks occur every now and then, which necessitate control measures. Typical of this kind of pest are the various

Lepidopterous larvæ (caterpillars) which appear at intervals as defoliators of lac hosts. A few examples are:—

1. *Semiothisa fidoniata,* Guenele. (*Geometridæ*), a false looper which defoliates *Acacia Catechu.*
2. *Selepa celtis, Moore.* (*Noctuidæ*). a defoliator of *Schleichera trijuga* and *Ficus glomerata.*
3. *Thiacidas postica,* Wlk. (*Lymantridæ*). a defoliator of *Zizyphus Jujuba* and *Z. Xylopyra.*
4. *Limacodidæ* or nettle grubs including *Parasa sp. Belippa laleana, Belippa sp.* and *Natada sp.* on various lac hosts.
5. *Hieromantis ioxysta,* Meyr (*Schreckenstineidæ*). a roller on *S. trijuga* leaves. This species is an alternative host of the useful species *Microbracon hebetor* (see Chapter XIX).

Such enemies may be killed by either stomach poisons or by contact poisons. An effective stomach poison is arsenic, sprayed on the leaves of the trees attacked, and which is eaten with the leaves. Such a spray may be made as follows:— **Lead Arsenate spray.**

Lead arsenate paste	...	...	1 oz.
Water	...	...	1 gallon.

Among contact sprays nicotine is effective. It should be sprayed on pest infected trees. An easily made formula is the following:— **Nicotine spray.**

Tobacco leaves	...	...	1 seer (2 lbs.).
Soft Soap (Karunj)	...	...	2 ozs.
Water	...	...	8 gallons.

The water should be heated in drums and the tobacco leaves and soap added. The mixture should be allowed to boil for ½ an hour, water being added to compensate for loss by steam and evaporation. The solution may then be allowed to cool, decanted and used as required.

Other biting insects include the weevil *Myllocerus cardoni,* Mshll. on a wide range of host plants, and the *Orthopteron, Sathrophyllia rugosa,* which bites through the young shoots of *Butea frondosa* Palas.

The possibility of Locust invasion is remote in the major area of lac cultivation. Locusts have visited Chota Nagpur on only one occasion during the last eight years. This was the migratory locust *Schistocerca gregaria,* Forsk. **Locusts**

Locusts appear in one of the following forms.

1. Hoppers or immature form.

2. Flying adults, of which two types occur.

   (*a*) Insects composing the swarm a pinkish colour. These are immature and may settle and feed.

   (*b*) Insects composing the swarm, dark brown to black coloured. These are mature insects which may settle, mate and lay eggs, from which hoppers will eventually hatch.

A flying swarm can often be prevented from settling by noise; beating drums or tins with sticks will frequently drive away a swarm elsewhere, to settle. Should the insects settle they should be collected by hand or by sweeping and burnt, or they may be crushed. Flame throwers and sprays have been shown not to be very effective. Baits may also be used at this stage and can be very effective: cf. below.

Eggs are laid in holes in the ground, 2"—8" deep, usually in a restricted area, the egg mass in the hole may contain from 40—100 eggs. Hoppers emerge about 2 weeks later. Breeding grounds should if possible be ringed with trenches 1 ft. wide and 18 inches deep with vertical sides. Hoppers which fall into these trenches may be killed with a mixture of kerosene oil and soft soap, kerosene should be added to the soap which is stirred until no more will go into the mixture, a jelly like mass will result, this semi-liquid mass is then diluted, 4 gallons of water to each gallon of kerosene used.

The progress of hoppers on the move should be barred by trenches in their line of advance into which they can be driven and killed. The older the hopper the bigger must be the trenches.

Poison baits are also very effective particularly against hoppers. For example—

Bran	40 seers.
Sodium fluosilicate	1 seer.
Gum	1 „
Water	15 galls. approx.

The 1 seer gum may be substituted by 1 seer salt. The rate of application may be said to be roughly 1 maund of bran to $2\frac{1}{2}$—3 acres. It should be scattered thinly and evenly.

Reports of locust invasion should always be made at once to local authorities for transmission to the Central Locust Bureau in Delhi.

PLATE XIV.

Twigs of *Zizyphus Jujuba* (Ber).
Badly attacked by *Aspidiotus orientalis*.

2. *Sucking Insects.*

Among Sucking insects are included the *Coccids* (Scale insects and mealy bugs) and other *Hemipterous* insects. Of these the most important is the *Coccid, Aspiodiotus orientalis,* Newst. a serious pest of *Zizyphus Jujuba* (Ber) and *Schleichera trijuga* and to a less extent of *Zizyphus Xylopyra* (Ghont) and *Butea frondosa* (Palas). The attack is serious, growth is retarded and Ber at any rate may be killed if the attack is severe ; affected trees cannot be utilised satisfactorily as lac hosts as *A. orientalis* colonises the branches which are therefore no longer available for the settlement of the lac insects. *A. orientalis* is in addition an alternative host for the lac parasites *Tetrastichus purpureus* and *Marietta javensis,* the former acting as a primary and secondary, and the latter as a secondary parasite of the *Coccid.* Other parasites bred from this species at Namkum were *Aphytis chrysomphali,* Mercet. *Comperiella bifasciata,* How. and *Physcus sp.* (near *flaviventris* How). It is largely young trees which are attacked, well grown trees appear to acquire immunity. As control pruning and spraying with Lime Sulphur were originally found to be effective. Lime Sulphur may be prepared as follows:— **Scale insects.**

Lime	...	...	...	50 lbs.	**Lime Sulphur spray.**
Sulphur	...	...	...	100 „	
Water	...	...	...	140 gallons.	

The water should be warmed and the whole of the lime added as *Quick* lime, when the lime has become slaked, the sulphur is added and the solution heated and stirred until it boils, it should be kept boiling until it becomes a dark brownish yellow colour. The spray is best used tepid to warm. The cost of this control lay between Rs. 25—35 per thousand trees of 6'—10' in height. Recent work points to the conclusion that *A. orientalis* at Namkum is becoming immune to Lime Sulphur spray, preliminary tests with a completely refined low boiling petroleum distillate have given promising results. Waste engine oil also showed promise, and is being further investigated.

Other *Coccid* pests of lac host trees are *Lecanium longulum,* Douglas on *Acacia Catechu* (Khair) *Flemingia congesta, Cajanus indicus* and *Acacia Farnesiana ; Icerya ægyptiaca* Doug ; *Chionaspis sp.* etc. Contact sprays should be used against them if their attack is serious.

A useful spray against this type of enemy is a Kerosene Soap emulsion made as follows:—

Stock.

Kerosene oil	...	...	...	2 gallons.	**Kerosene emulsion.**
Karunj soap	...	...	...	½ lb.	
Water	...	...	...	1 gallon.	

The soap is dissolved in water heated to boiling, the kerosene is added to the mixture while still boiling hot and stirred until a thick creamy fluid results. The success of the spray depends to a considerable extent on the efficiency of the stirring. The solution may be kept in sealed drums. This stock if properly made should adhere to glass without separating into oily particles, and

when spread with the ball of the finger should form a fine continuous film. It will keep for a considerable time. If insufficiently stirred the oil will separate and collect at the top.

For use the stock is diluted with water, 1 part stock to 3 parts water, and at this concentration does not scorch the foliage. Tests should however be made with various dilutions as the susceptibility of foliage to scorch varies very considerably. Spraying should be done preferably in the evening or on cloudy days, not in the full heat of the sun as this tends to cause scorch.

It should be pointed out that these sprays are all fatal to lac, and should not be utilised on lac infected trees.

Other Hemiptera.

Machærota planitiæ, Dist. is a *Cercopid* pest of *Zizyphus Jujuba* Ber and to a less extent of *Zizyphus Xylopyra* Ghont. The nymphs form small calcareous tubes in the feeding stage, on the branches, and cause "die back" by sucking the sap from the terminal shoots. Badly infected branches should be cut and burnt. *M. planitiæ* is an alternative host of the lac parasite *Eupelmus tachardiæ.* The *Pentatomid, Tessaratoma javanica,* Thumb. is a pest of *Schleichera trijuga* Kusum, the bugs occur in large numbers and suck the sap from the shoots and cause "die back". Hand collection is advised as control, as it is comparatively easy to collect and kill 100% of so large and conspicuous an insect if the trees are not very large.

3. *Boring Insects.*

Borers.

Borers include the larvæ of insects which bore into the roots, trunks or branches of host trees. Examples are the larva of the *Longicorn* beetle *Celosterna scabrator* which damages, Khair; the larvæ of certain *Buprestid* beetles in particular, species of *Sternocera* which attack Khair and other hosts; and the larva of the moth *Inarbella tetraonis* which attacks species of *Albizzia, Zizyphus Jujuba* etc.

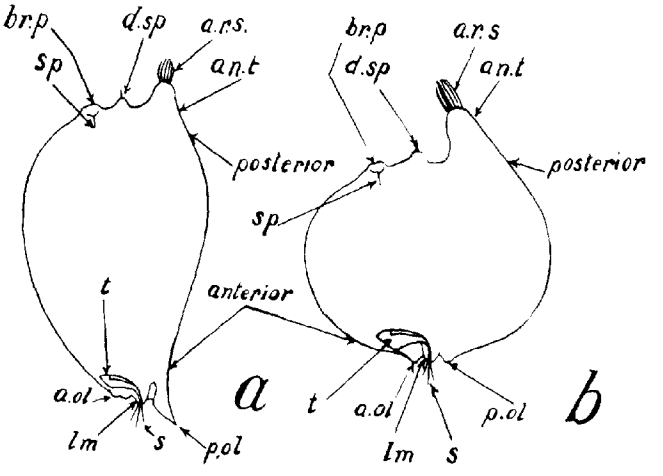
Borers are extremely difficult to control. Usually the best method is to trap or catch by hand the adults, which usually emerge at certain definite times of year, often at the break of the Monsoon, and in the case of the examples referred to, are fairly conspicuous insects.

If the borer affects the growing tips or terminal shoots, those badly infected should be cut and burnt.

Injection of poisons into the borer holes is often very effective, where these are easily visible as they are in the case of *I. tetraonis* and *C. scabrator* Liquids injected must not be harmful to the trees themselves, the following may be utilised:

Paradichlorbenzine	...	...	6 oz. (fluid).
Petroleum ...	...	...	4 gallons.

Burma Shell Co. Furnace oil may be substituted for petroleum and is cheaper. About 8 ccs should be necessary for each dose, and a 4 gallon tin of oil will be sufficient for nearly 2,000 trees.



TEXT FIGURE IX

LACCIFER LACCA.

(*a*) Shape of adult females which grow close together and overlap one another (lac test removed). (*b*) Shape of adult females which grow more or less separately (lac test removed).

an.t.	anal tubercle.	lm.	rostrum (labium).
a.ol.	anterior oral lobe.	p.ol.	posterior oral lobe.
a.r.s.	anal ring setæ.	s.	spiracle.
bar.p.	brachial plate.	t.	tentorium.
d.sp.	dorsal spine.		

From, Negi, P. S. Bull. Ent. Res. Vol. XXV. pt. 4. December 1934.

CHAPTER XXII.

SOME GENERAL NOTES ON THE LAC INSECT, LACCIFER LACCA.

Species of Lac insects.

A great deal has been written on the classification of lac insects by a number of authors. Mahdihassan (1923) separated lac insects into a number of species on what he termed a physiological classification. His system being based on the nature of the lac secreted and on the secretionary activity. To these species he assigns for reasons unknown, the Generic name *Lakshadia,* among them are *L. nagoliensis, L. indica, L. chinensis,* and *L. mysorensis.* It is claimed that the lacs secreted by them have different chemical and physical properties.

That the character of the lac secreted is no basis on which to draw up a classification is clear, when the variation in samples of lac from the same strain of insect on the same host tree in the same district, during the Katki and Baisakhi crops is considered. This variation is even greater if different hosts trees are utilised even in the same district, and if different districts are considered the differences are greater still. It cannot be held that an individual strain secretes a typical form of lac.

Chamberlin in his Monograph of the *Tachardiinæ* (1923) and again in his supplement to this work (1925), severely criticises Mahdihassan's classification and appears to hold the view put forward above. He describes a number of species and includes two definite species in the group *Laccifer lacca* Kerr, these are *L. ebrachiata,* Chamberlin. and *L. lacca,* Kerr. He suggests that some of Mahdihassan's species may be races or forms, and says, "It is quite possible, and indeed probable, that *lacca,* with further study of abundant and fresh material, will be found to split up into a number of local races or sub-species." Beeson (1924) has put forward the following point of view. "It may be said that from the economic aspect of the problem the lac cultivator is not assisted greatly by the knowledge the *Tachardia lacca* is on the one hand a single species, or is on the other hand a group of morphologically similar species. However in regarding it as one species he will be supported by the majority."

In giving specific rank on account of small differences in lengths and breadths of anal and brachial tubercles, or on account of differences in the shape of insect and resin deposited, the following points put forward by Negi (1934) should be taken into consideration.

"Owing to the deposition of resin the shape of the adult female lac insect either takes the form shown in (Text Figure IX) 1 a or 1 b. The latter represents the shape of those insects which grow more or less separately, without coming into very close contact with one another. The former shape is assumed by insects which coalesce or overlap.

In the females of the type shown in (Text Figure IX) 1 b the rostrum (lm) is situated ventrally at about the middle of the insect, whereas in those of the other type shown, it is situated at the extreme anterior end. In the females of the intermediate shapes, the rostrum lies ventrally in the anterior half of the body . . . . . In such females (type b.) the rostrum lies almost at a right angle to the other mouth parts and the crumena lies opposite to the tentorium and the mouth parts enclosed in it. But in the females of the type represented by (Text Figure IX) 1 a the direction of the tentorium and the mouth parts enclosed in it is totally changed; the hind end of the tentorium is directed towards the anal end of the female, and the rostrum lies in the front of the tentorium at an obtuse angle and the crumena lies over the tentorium."

The object in quoting the above at length is to make it clear that if two females of the same species, growing on the same host in the same district for the same crop can differ so widely in shape and disposition, any attempt to sub-divide the species into species or sub-species on minute differences of shape etc. must be carefully avoided.

That the trivoltine lac in Mysore on *Shorea talura* referred to in Chapter I is not a true species, but only a strain behaving in this way due to climatic conditions is suggested by the fact that when a consignment was inoculated on *Shorea talura* at Namkum, it passed through only two and not three life cycles during the year.

There seems to be little doubt that the lac insect in the major lac-growing areas is actually one species *Laccifer lacca,* and that there are two main strains, the Kusmi and the Rangeeni with minor morphological differences and producing a slightly different type of resin. An account of the behaviour of these two strains, and of the importance of this matter from the point of view of the practical cultivator is given in Chapters I and X—XIV. It also seems probable that a number of sub-strains may occur, with preferences for certain host plants, these may or may not bear small morphological differences. Also it seems probable that, if some of these sub-strains are transferred from their own host to another host many of the characters which might be of use in identifying the sub-strain may be progressively lost.

Lac insect and its hosts.

It will be seen from the foregoing chapters that the lac insect is not confined to a given Genus within a Family or even to a single Family (though a large majority belong to the Family *Leguminosæ*) for its host plants, nor are the Families in which lac hosts are to be found closely related. Further, of two closely related species within a Genus one may be a lac host and the other not. An example of this may be quoted. *Zizyphus Jujuba* (Ber) is a lac host *Zizyphus rugosa* (Pithaur) is not a lac host.

A study of two members of the Family *Leguminosæ, Acacia Catechu* (Khair) an excellent lac host and *Cassia Florida* which is not a lac host gave the interesting result that among the factors which influence the suitability of a

given species as a lac host, sap-reaction and sap density are likely to be of importance. The sap-reactions of good lac hosts were found in general to approach neutrality (*e.g.*, P.H. 5·8—6·0) whereas those of non-lac hosts were found to show either a greater acidity, examples are *Cassia florida* and *Shorea robusta* (P.H. 5·0—5·4) or a greater akalinity *Zizyphus rugosa, Dalbergia Sisso, Aleurites Fordii* (P.H. 6·2—6·8). The sap-density of good hosts ranged from 0·14 to 0·1728 and that of a number of non-lac hosts from 0·1955 to 0·2312. It was observed that the availability of food supply and seasonal growth periods did not offer any explanation of the unsuitability of *Cassia Florida* as a lac host.

Zizyphus Xylopyra Ghont a satisfactory lac host in the Central Provinces, but one that will not bear a lac crop in this District has a sap-reaction (P.H. 6·0) within the range of that of known satisfactory lac hosts. In this case there must be some further factor which precludes its use as a lac host at Namkum. This may possibly be sap density. Even among lac hosts there are sometimes found two types of a given species, one of which takes a satisfactory lac infection and yields a healthy lac crop, the other either produces a poor crop only or will not produce a crop at all. The two types are botanically indistinguishable, but are usually distinguished by the raiyat by slight differences in the shape of the leaves, colour of the bark or other such features. Such types are termed biological races because though botanically indistinguishable, yet biologically they are easily separable by means of the preference of the lac insect. This phenomenon is found among certain lac hosts only, not among all.

Biological Races of Lac hosts.

Two distinct types of Kusum occur in Chota Nagpur and are called charka and kareya. Kareya is an excellent lac host, and where Kusum is mentioned in this book, kareya Kusum is meant. Charka if infected with lac takes badly and either a poor or negligible crop is produced. The differences between the two are slight, they are distinguished by the raiyats by leaf shape and also growth habit, also the trunk and leaves of kareya Kusum are darker in colour, charka Kusum having a whitish coloured trunk and a yellow green coloured leaf. Such differences can only be learnt by experience and are impossible to describe on paper, they are not strictly defined, and intermediate types occur.

At Bhinjpur near Raidih, Ranchi District according to Mr. Fraser, three races of Kusum are distinguished, there are however intermediates between them. The first type bears small crinkled or curled leaves and is a good lac host, it produces however only short shoots and therefore long encrustations cannot be obtained. The second type has medium sized leaves which tend to be narrowed towards their apex and may be so much so, as to resemble somewhat the jungle mango, this type takes a poor lac infection. The third type is the best lac host, the leaves are large and shiny green with some slight resemblence to the Mahua (*Bassia latifolia*). An interesting point is that after pruning, the leaves produced in the first year on all three types tended towards the large leaf, of type three, later however they become once again segregated.

Fraser also quotes the interesting fact that certain branches of a Kusum tree may be charka, while the tree as a whole is kareya. These branches are said to be bone white in colour. Such branches may be pruned and give rise to healthy kareya shoots. Specimens of leaves, fruits, etc., were submitted to the Forest Botanist, Dehra Dun, who stated that these types did not differ botanically.

There are two races of *Butea frondosa* (Palas) in this Province, one of which is the excellent lac host referred to in previous chapters, the other will not take a lac infection, there is however no apparent botanical difference between them. The raiyat method of differentiation is to make an incision into the bark, if the inner wood is reddish in colour, the tree is a lac host, if the inside colour is whitish the tree will not take an infection. This latter type is rare.

Among *Ficus* lac hosts a number of biological races seem to occur, also the behaviour of any given *Ficus* host seems to vary very greatly from one district to another. Dumber, *F. glomerata* for example in some districts is a good Baisakhi host whereas in others it is a failure during this crop. Pakri, *F. infectoria* on which lac is cultivated extensively in the Raidih district in this Province is, according to Mr. Fraser divided into several races, one of which is a good Baisakhi host, and another of which, though a poor Baisakhi host, is quite valuable for the Katki crop, infection. A number of types of *F. religiosa*, (Pipal) are recognised in Bihar separated by small differences in the length and shape of their leaves, some of these are considered more valuable as lac hosts than others by the villagers.

Albizzia stipulata (Siris) is common in the Ranchi District having been planted as a shade tree in Tea Gardens. *A. stipulata* has previously been mentioned in this book (Chapter XIV), it will take a lac crop, but infection generally leads to the death of the tree after it has been cropped. Two races occur known as kala and safed, the appearance is extremely similar, the former being slightly darker in leaf and trunk than the latter. Kala Siris will carry a lac crop, on safed the larvæ having settled on the twigs die after a few weeks.

There are indications that there are two races of *Acacia Catechu* (Khair), one of which is a good lac host, and the other of which a poor or non-lac host; according to Mr. Sabharwal of the Forest Department, Bihar, the former may be recognised by its rough bark and black coloured heart, from the latter, whose bark is smoother and whose heart is reddish in colour.

It is curious however that there do not appear to be biological races of *Zizyphus Jujuba* (Ber), in the experience of this Institute all trees of this species appear to be lac hosts.

In Assam it seems possible that two races of *Leea crispa* occur, as reports state that some trees give yearly better lac than others.

It is worth recording that in every instance the race which is a non-lac host is distinctly in the minority, the majority of trees of a host species being satisfactory lac hosts.

The cultivator should obtain local opinion as to whether host trees in his district are lac hosts or not, until he is able to distinguish the races himself. Raiyat opinion in these matters will usually be found to be correct. Failing this when carrying out infections of trees as to which there is any doubt, the preliminary infections should be made on a small scale only.

This phenomenon of biological races has been receiving attention at Namkum and a number of experiments have been carried out, mainly with kareya and charka Kusum.

At Sabaya it was found that charka Kusum yielded good results at the 3rd infection. At Namkum it was found that the injection of dilute ammonia solution into certain charka trees was beneficial in improving the yields obtained. (cf. page 130.).

Origin of Lac.

There can be no doubt that the lac insect absorbs the sap from its host *via* the proboscis into the alimentary canal, where it undergoes metabolic change, and serves to nourish the insect and that the lac is secreted by glands in the insect body and is therefore animal in origin. The view that the insect acts as a strainer or filter on the sap obtained from the host, part being absorbed as food and the remainder excreted as lac is quite untenable.

Parry in his book, "Shellac" (1935) has stated the case against this second point of view concisely in the following words.

"In the first place, it is idle to suggest that the juice of so many different host trees is substantially identical in character as would otherwise have to be the case. Further, for large quantities of solid resin to be ambulatory in the plant, a solvent would be required so that the resin could move through the tissues of the plant. In those cases we know of, such a solvent exists; for example, in the case of turpentine, copaiba, and many other resinous exudations. The solvent is always an essential oil with a strong odour. The tree can be artificially tapped, the oleo-resin exudes, the essential oil with its powerful odour can be recovered by distillation and the resin obtained in the solid condition. In other cases, the oil and resin may be pathological secretion induced only by wounding the tree, such as is the case with Balsam of Peru; but there again the solid matter is dissolved in an odorous liquid, and can be obtained from the tree without intervention of any animal life. The extraction of either the normal life products of a tree, or of such products as may be induced pathologically when these products are not normally excreted or secreted by the trees, does in accord with general experience, weaken the tree in respect of its manufactur of such products, and resting times must be given to the trees if they are to be successfully exploited. This is true of such trees as those that yield tur-

pentine or rosin and many others, and is, from a theoretical point of view, sure to be true of trees called upon to act as hosts for the lac insects."

Gummosis. Mahdihassan (1936) considers that the lac insect is beneficial to its host trees, he assumes without the least apparent evidence that the lac insect thrives only or largely on trees which are themselves unhealthy, and that the feeding of the lac insect reduces the diseased condition of the host. This hypothetical disease he terms "gummosis" whose symptoms are abnormal growth of gum producing bacteria which give rise to an excess of gum in the plant tissues. The lac insect in feeding, draws off the gum laden juices and also presumably some of the gum producing bacteria, thereby relieving the disease to a greater or less extent. There appears to be no evidence whatsoever for this theory, and the chemical constitution of lac is remote from any gummy matter which might occur in the plant sap.

In actual fact there can be no doubt that the lac insect is an insect pest of its host trees, and is in no way beneficial to them, but is a pest, which is however purposely cultivated on account of the commercial value of its secretion. The majority of species among the *Coccidæ*, of which *L. lacca* is a member, are pests of various trees and plants. Many of them produce a secretion as a covering for their bodies. It is not to be suggested that *Aspidiotus perniciosus*, the San Jose's Scale or *Icerya purchasi* the cottony cushion scale, or even that members of the *Tachardina*, for example, attack exclusively unhealthy plants to which they are definitely beneficial, and it seems unnecessary to assume without evidence that, out of the *Coccidæ*, of which there are a very large number of species, the lac insect alone is unique in beneficial behaviour.

The actual evidence is all the other way. Inspection of a number of trees of the same species some of which are infected with lac and others not, almost invariably shows that the infected trees have less vigorous growth smaller canopy and fewer and less luxuriant leaves than the uninfected trees.

Heavy infection with *L. lacca* is frequently damaging to the trees infected. A number of *Acacia Farnesiana* which were heavily infected with lac in July 1936 at Namkum were killed. At Sabaya it has been observed that infection of *Albizzia stipulata* with lac frequently results in the death of the tree before or after cropping.

After taking several successive crops from certain lac hosts it is found that they do not put out good shoots and it is necessary to rest them. Infection of *Anona squamosa* with lac in Burma adversely affected the fruiting and even killed some trees.

It has been explained in the chapter on Palas and elsewhere that the partial cutting of the crop from Palas trees in April-May relieves the tree of part of the drain made by the insects feeding and enables the tree to support the remainder of the crop to give brood in July.

All the above observations are in favour of the theory that lac is an ordinary pest insect and do not fit in with the gummosis hypothesis.

Now to return to the phenomenon of biological races of lac hosts, Mahdihassan claims that the hosts races are those trees suffering from the predisposing gummosis factor, and that the non-hosts trees are not infected with this disease.

It has been stated (loc. cit.) that of any species the minority are of the non-host race, the majority being lac hosts. Thus according to the gummosis theory, it would be necessary to assume that the majority of any given species suffer from a disease, in fact the so-called diseased condition is normal and the so-called undiseased abnormal.

Mahdihassan 1936 states that Forest, fires and frosts and floods are predisposing factors for gummosis and says that localities where lac is cultivated (*i.e.*, in Sind) are subject to these factors. These factors however are seldom met within the great lac-growing tracts of Chota Nagpur which produce the highest quality lac grown in India. He quotes also the method of differentiating the races of Palas, mentioned early in this chapter, stating that the reddish wood i sa proof that the tree is suffering from gummosis; because Palas gum is red. No one denies that Palas trees secrete gum, but a reddish colour hardly proves a tree to be attacked by disease in the case of a gum secreting tree just the reverse. The theory also fails to account for charka and kareya Kusum, in neither of which is gum secreted.

Mahdihassan 1936 also states that hot dry winds "all tending to wither and act as nature's pruning knife" are beneficial to the host in bringing about the right predisposition for lac infection. This statement unsupported by any evidence is hardly creditable. It is well known to the cultivators throughout Bihar that hot dry winds are harmful to the lac crop. Palas and Kusum both of which provide shade and protection from sun and dry hot winds are the only hosts on which lac will survive the hot weather to give brood in July in certain of the more hot and arid districts of Chota Nagpur.

In the case of *Dalbergia latifolia* a lac crop was only obtained after repeated infection. If gummosis was a predisposing factor one would expect the first infection on a tree suffering from this disease to be very successful and subsequent infections less so, as the beneficial action of the lac insect reduced the disease.

In general the more healthy the tree, the more healthy the lac crop that will be obtained from it, and a healthy tree is less likely to be damaged or killed by lac infection than an unhealthy one. In this connection the fact already recorded in this chapter that greater yields of resin were obtained from manured than from unmanured plants may be remembered.

Mahidhassan 1936 has also said that heavy pruning is good for gummosis, and therefore good for lac cultivation. The facts are the reverse, heavy pruning results in a delayed and poor response on the part of the host tree, in the case of Kusum necessitating a rest of 2-3 years, whereas Kusum trees lightly pruned are ready for infection after 18 months. The resulting shoots from heavy pruning are in no way more suitable for infection than those from light pruning and are much fewer in number.

The explanation is in actual fact much more simple and rests on the physiological condition of the tree concerned. In the early part of this chapter it has been shown that lac thrives on trees having sap reaction and density within certain definite limits. It was found that Kareya Kusum an excellent lac host had a sap reaction of P.H. 5·8-6·0, *i.e.*, approaching neutrality, and that the sap reaction of Charka Kusum, (*i.e.*, P.H. 5·4-5·8), the poor lac host was outside the range of that of good lac hosts. It was also found that the injection of alkali such as ammonia and lime into charka Kusum immediately improved its properties as a lac host.

Sap reaction is not considered to be the *only* factor concerned in the determination as to whether a tree is a lac host or no. *Zizyphus Xylopyra* which will not carry a lac crop at Namkum has a P.H. of 6·0: sap density and also probably other factors are important.

Climatic and soil conditions are believed to account for differences in sap reaction density, etc., among given species.

Lac secretion.

The secretionary activity of the lac insect in the four lac crops is not identical. Although the Baisakhi crop takes nearly three times as long to mature as the Katki, approximately the same amount of lac is secreted by the lac insects in each. In both crops during the first 2-3 weeks very little resin secretion occurs, and until male emergence resin secretion is very slow. In the Katki crop male emergence occurs about 1-2 month after larval settlement and the Baisakhi about 4-5 months after larval settlement. The fact that the Baisakhi takes four times as long to reach the stage of development at which males are due to emerge is probably due to the low temperature conditions which occur during the months November-December, January-February compared with the temperature during the first month of the Katki crop, *i.e.*, July.

After male emergence and fertilisation, resin secretion proceeds at a rapid and regular pace upto 1 month to six weeks before swarming in the case of the Baisakhi crop and to 10 days before swarming in the case of the Katki crop. Hence in the Baisakhi crop the period of greatest secretion is the 2 months after emergence of the males that is during the months February-March to April-May.

The fact that this secretionary activity is not due to fertilisation is apparent from the observation that a similar phenomenon is observed in strains from which males have been eliminated and fertilisation prevented.

Premature cutting of the Baisakhi crop in April-May as practised in hot arid districts, where $\frac{1}{3}$rd the crop is left on the tree to give rise to brood and $\frac{2}{3}$rd is cut is therefore justified, in that practically no lac secretion is lost due to this premature cutting. The advantages are that the trees are relieved of the drain of the insects feeding upon them; that this partial cutting acts as a pruning giving rise to new shoots on which the larvæ from the remaining $\frac{1}{3}$rd can settle in July; and that chowkidar charges are thereby reduced. This question is fully explained in Chapter XII.

In the case of Aghani and Jethwi crops, the growth periods, as has already been explained, are nearly equal in duration. Resin secretion in both Aghani and Jethwi crops continues right up to the time of swarming in both seasons, and any premature cutting therefore means a loss in the amount of resin produced. As secretion continues in the Katki crop until shortly before swarming is due, any premature cutting in this crop means a loss in the amount of resin produced, and in fact the Katki crop is rarely cut immature.

The Jethwi crop is seldom cut immature. The Aghani crop (that portion not required as brood) however is cut in the Hindi month Aghan (November-December) when it is not fully mature. This practice is wasteful as the resin that would have been produced between the time of cutting and maturity is lost. The object of this cutting is partly the need to get the money for the lac as soon as possible, and partly to lessen the chance of theft which may occur during the remaining weeks of the crop.

The resin produced during the Aghani crop is nearly twice as much as that produced during the Jethwi: This and the weather conditions under which the crop develops explains the reason why the Aghani is the commercial crop, whereas the Jethwi is largely a brood crop grown for the infection of the Aghani.

Another interesting point is that the resin produced by the lac insect, during the Aghani crop is nearly three times greater than that produced during either Baisakhi and Katki crops, and that produced during the Jethwi crop nearly $1\frac{1}{2}$ times greater. Thus the Kusmi strain of *L. lacca* is $2\frac{1}{4}$ times as efficient as the Rangeeni.

Sex Ratio.

As regards the percentages of males and females in the lac crops, taking an average over five years it will be seen, Table XXI and XXII, that males are

present in greater numbers in the Baisakhi crop than in the Katki, and similarly in the Jethwi than in the Aghani.

TABLE XXI.

Crop.	*Percentage males.*	*Percentage females.*
Baisakhi ...	35·1%	64·9%
Katki	22·9%	77·1%
Jethwi	26·1%	73·9%
Aghani	20·6%	79·4%

The male percentage is slightly higher 29% in the Rangeen crops than in the Kusmi 23·35%. The percentage of males to females throughout the five years under review has been 26·2% to 73·8%.

It will be seen that the percentage of males in the Baisakhi crop is noticeably higher than in the Katki, and that the percentage in the Jethwi is rather higher than in the Aghani.

The controlling factors of the percentage of males in a crop have not been ascertained. Larvæ once they have emerged do not change their sex. Negi 1929 has shown that it is possible to identify correctly 89·6% of the males and 92·6% of the females with a binocular Microscope at the time of emergence. Further, regular examinations carried out weekly throughout the crop from the time of infection to the time of male emergence show a remarkable uniformity in the percentages of males and females week by week. The controlling factors for sex ratio among the larvæ must therefore be sought among conditions occurring during the development of the ovules in the mother insect.

Among such factors humidity is probably one of importance, the progeny of lac grown under humid conditions having a higher percentage of males than that grown under arid conditions. It will be seen from the above figures that the percentage of males in the progeny of the Katki crop grown under humid conditions is noticeably higher than the male percentage in the progeny of the Baisakhi crop which is grown under arid conditions. The same may be said of the Kusmi crops. In the early months the Aghani crop is grown under humid conditions, the percentage of males in the progeny is higher than that of the progeny of the Jethwi crop grown under arid conditions.

It should however be pointed out that although the Katki crop is grown under extremely humid conditions and the Baisakhi under extremely arid conditions, the percentages of males is only 22·9% in the one case and 35·1% in the other, a difference in percentage of only 12·2%, the statement made by Mahdihassan that soil moisture produces a progeny *rich* in males is not in accordance with the facts.

The quality of the lac produced under moist conditions is in general lower than that produced under dry conditions. Baisakhi lac grown under dry conditions is higher in quality than Katki lac grown under moist conditions. It is also well known that the highest quality lac comes from Chota Nagpur which may be described as arid, whereas lac grown in damp climates as Assam, Burma, and in South India, is of a lower quality usually more brittle and frequently with a reddish as opposed to a yellowish colour.

The theory that lac grown on high ground is better for purposes of brood, than lac grown on low land where sub-soil moisture may be expected, has been put forward by Mahdihassan (1936). It is not however in accordance with facts, during the Baisakhi crop, in hot arid districts, it is only lac growing on trees on low lying land and such places where sub-soil moisture is to be found that is able to survive the hot weather to give brood in July. During the Katki crop, humidity is high, and the difference in male percentages in the progeny of lacs growing on high or on low land is unlikely to show any significant variation.

TABLE XXII

Percentages of Males and Females in various strains in the lac crops during the last five years.

Crop.	Strain	Percentages		Average for the crop	
		Males.	Females.	Males.	Females.
Baisakhi 1931-32 ...	Palas × Palas	34·0%	66·8%		
	Palas × Ber	30·8%	69·2%	35·1%	64·9%
	Ber × Ber	40·0%	60·0%		
Jethwi 1932 ...	Kusum × Kusum	24·4%	75·6%	24·4%	75·6%
Katki 1932 ...	Palas × Palas	26·9%	73·1%		
	Palas × Ber	27·1%	72·9%		
	Palas × Khair	24·8%	75·2%	25·8%	74·2%
	Ber × Ber	29·0%	71·0%		
	Ber × Palas	25·5%	74·5%		
	Ber × Khair	23·8%	76·2%		
Aghani 1932-33 ...	Kusum × Kusum	23·9%	76·1%		
	Kusum × Khair	24·3%	75·7%	24·1%	75·9%
Baisakhi 1932-33 ...	Palas × Palas	39·3%	60·7%		
	Palas × Ber	34·5%	65·5%	38·9%	61·1%
	Ber × Ber	41·1%	58·9%		
	Ber × Palas	40·6%	59·4%		
Jethwi 1933 ...	Kusum × Kusum	26·6%	73·4%	26·6%	73·4%
Katki 1933 ...	Palas × Palas	28·5%	71·5%		
	Palas × Ber	27·3%	72·7%		
	Palas × Khair	26·3%	73·7%	26·6%	73·4%
	Ber × Ber	26·0%	74·0%		
	Ber × Palas	30·9%	69·1%		
	Ber × Khair	22·4%	77·6%		
Aghani 1933-34 ...	Kusum × Kusum	22·5%	77·5%	21·9%	78·1%
	Kusum × Khair	21·4%	78·6%		
Baisakhi 1933-34 ...	Palas × Palas	34·3%	65·7%		
	Palas × Ber	35·8%	64·1%		
	Ber × Ber	33·7%	66·3%	34·5%	65·5%
	Ber × Palas	34·2%	65·8%		
Jethwi 1934 ...	Kusum × Kusum	30·9%	69·1%	30·9%	69·1%
Katki 1934 ...	Ber × Palas	15·8%	84·2%	16·8%	83·2%
	Ber × Khair	18·1%	81·9%		
Aghani 1934-35 ...	Kusum × Kusum	16·0%	84·0%	17·8%	82·2%
	Kusum × Khair	20·3%	79·7%		
Baisakhi 1934-35 ...	Palas × Palas	35·6%	64·4%		
	Palas × Ber	34·6%	65·4%	35·1%	64·9%
	Ber × Palas	35·2%	64·8%		
Jethwi 1935 ...	Kusum × Kusum	27·4%	72·6%	27·4%	72·6%
Katki 1935 ...	Palas × Palas	22·5%	77·5%		
	Palas × Khair	21·1%	78·9%		
	Ber × Ber	22·5%	77·5%	22·4%	77·6%
	Ber × Palas	23·2%	76·8%		
	Ber × Khair	22·5%	77·5%		

Percentages of Males and Females in various strains in the lac crops during the last five years.—(Contd.).

Crop.	Strain	Percentages		Average for the crop	
		Males.	Females.	Males.	Females.
Aghani 1935-36 ...	Kusum × Kusum	18·5%	81·6%		
	Kusum × Khair	17·8%	82·2%	18·1%	81·9%
Baisakhi 1935-36 ...	Palas × Palas	33·2%	66·8%		
	Palas × Ber	29·9%	70·1%	32·0%	68·0%
	Ber × Ber	31·1%	68·9%		
	Ber × Palas	34·1%	65·9%		
Jethwi 1936 ...	Kusum × Kusum	21·3%	78·7%	21·3%	78·7%
Katki 1936 ...	Palas × Palas	24·1%	75·9%		
	Palas × Khair	24·4%	75·6%		
	Ber × Ber	20·0%	80·0%	23·0%	77·0%
	Ber × Palas	22·9%	77·1%		
	Ber × Khair	23·5%	76·5%		
Aghani 1936-37 ...	Kusum × Kusum	20·1%	79·9%		
	Kusum × Khair	21·9%	78·1%	21·1%	78·9%

APPENDIX I.

List of host trees mentioned, with their Families, Botanical and Vernacular Names.

Botanical Name.		Family	Vernacular Names.
Acacia arabica	...	*Leguminosæ*	Babul, Kikar (Punjab), Babla (Bengal), Karugai (Madras).
Acacia canescens	...	,,	——
Acacia Catechu	...	,,	Khair, Sha (Burma).
Acacia concinna	...	,,	——
Acacia Farnesiana	...	,,	Kastura.
Acacia latronum	...	,,	——
Acacia leucophlæa	...	,,	——
Acacia monilliformis	...	,,	——
Acacia pinnata	...	,,	——
Acacia suma	...	,,	San-kanta.
Albizzia lebbek	...	,,	Siris, Kokko (Burma).
Albizzia lucida	...	,,	Galwang (Assam).
Albizzia stipulata	...	,,	Siris.
Albizzia ordoratissima	...	,,	Airma bonsa (C. P.), Taung-Magyi (Burma).
Anona squamosa	...	*Anonaceæ*	Custard Apple, Awza (Burma).
Atylosia albicans	...	*Leguminosæ*	——
Atylosia mollis	...	,,	——
Bursera serrata	...	*Burseraceæ*	Thadi (Burma).
Berrya amonilla	...	*Tiliaceæ*	Pauk-nwe (Burma).
Butea frondosa	...	*Leguminosæ*	Palas, Paras, Dhak, Chheola (C. P.), Chhichra (Punjab), Pauk (Burma).
Butea superba	...	,,	Pauk-nwe (Burma).
Cæsalpinia coriaria	...	*Leguminosæ*	Angrezi imli (C. P.).
Cajanus indicus	...	,,	Arhar, Rarhar, Tur, Nandu (Assam).
Croton oblongifolius	...	*Euphorbiaceæ*	——
Dalbergia cultrata	...	*Leguminosæ*	Yindaik (Burma).
Dalbergia lanceolaria	...	,,	——
Dalbergia latifolia	...	,,	Shishum (C. P.).
Dalbergia Oliveri	...	,,	Tamalan (Burma).
Dalbergia paniculata	...	,,	Dhoben (C. P.).
Dicrostachys cinerea	...	,,	——
Dolichos falcatus	...	,,	——
Engelhardtia spicata	...	*Juglandaceæ*	Wakgru (Assam). Thitnu (Burma).
Entada scandens	...	*Leguminosæ*	——
Ficus altissima	...	*Moraceæ*	——
Ficus Bengalensis	...	,,	Giting (Assam). Banyan (Punjab), Bargat (C.P.).
Ficus carica	...	,,	Fig (Punjab).
Ficus Cunia	...	,,	Porho, Thadut (Burma).
Ficus glabella	...	,,	Putkul.

List of host trees mentioned, with their Families, Botanical and Vernacular Names. —(Contd.).

Botanical Name.		Family	Vernacular Names.
Ficus glomerata	...	*Moraceæ*	Dumber, Fig, Gular, Thapan (Burma).
Ficus hispida	...	,,	Kadut (Burma).
Ficus indica	...	,,	Nyaung-thabye (Burma).
Ficus infectoria	...	,,	Pakaur, Pakri, Nyaung-gyin (Burma).
Ficus nervosa	...	,,	Nyaung-peinne (Burma).
Ficus obtusifolia	...	,,	Nyaung-gyat (Burma).
Ficus religiosa	...	,,	Pipal, Bawdi (Burma).
Ficus Roxburghii	...	,,	Sinthapan.
Ficus Rumphii	...	,,	Prap. (Assam).
Ficus tsiela	...	,,	——
Flemingia congesta	...	*Leguminosæ*	——
Flemingia congesta var *semialata*	...	,,	Marda Noyi.
Grewia lævigata	...	*Tiliaceæ*	——
Grewia multiflora	...	,,	Bolmengo (Assam).
Kydia calycina	...	*Malvaceæ*	Boldabak (Assam).
Leea crispa	...	*Ampelidaceæ*	——
Leea robusta	...	,,	Gangma (Assam).
Nephelium litchi	...	*Sapindaceæ*	Litchi
Ougeinia dalbergioides	...	*Leguminosæ*	Panjan, Tinsa (C. P.).
Pentacme suavis	...	*Dipterocarpaceæ*	Ingyin (Burma).
Pithecolobium Saman	...	*Leguminosæ*	Rain Tree, Thinbaw kokko (Burma).
Polyalthia suberosa	...	*Anonaceæ*	——
Schleichera trijuga	...	*Sapindaceæ*	Kusum, Gyo (Burma).
Shorea obtusa	...	*Dipterocarpaceæ*	Thitya (Burma).
Shorea talura	...	,,	Jalla.
Zizyphus Jujuba	...	*Rhamnaceæ*	Ber, Plum, Kul, Elandai (Madras), Zi (Burma).
Zizyphus Xylopyra	...	,,	Ghont, Malhar (Punjab).

Where the Vernacular Name is used mainly or entirely in a special Province, the Province is given in brackets after the name. Other Vernacular names are the common names in general usage, particularly in Bihar.

APPENDIX II.

Key to Vernacular Names of Lac host trees.

Vernacular Name.	Botanical Name.
Airma bonza	*Albizzia odoratissima.*
Angrezi imli	*Cæsalpinia coriaria.*
Arhar	*Cajanus indicus.*
Awza	*Anona squamosa.*
Babla	*Acacia arabica.*
Babul	*Acacia arabica.*
Banyan	*Ficus Bengalensis.*
Bargat	*Ficus Bengalensis.*
Bawdi	*Ficus religiosa.*
Ber	*Zizyphus Jujuba.*
Boldabak	*Kydia calycina.*
Bolmengo	*Grewia multiflora.*
Chheola	*Butea frondosa.*
Chhichra	*Butea frondosa.*
Custard Apple	*Anona squamosa.*
Dhak	*Butea frondosa.*
Dhoben	*Dalbergia paniculata.*
Dumber	*Ficus glomerata.*
Elandai	*Zizyphus Jujuba.*
Fig	*Ficus glomerata.* / *Ficus carica.*
Galwang	*Albizzia lucida.*
Gangma	*Leea robusta.*
Ghont	*Zizyphus Xylopyra.*
Giting	*Ficus Bengalensis.*
Gular	*Ficus glomerata*
Gyo	*Schleichera trijuga.*
Ingyin	*Pentacme suavis.*
Jalla	*Shorea talura.*
Kadut	*Ficus hispida.*
Karugai	*Acacia arabica.*
Kastura	*Acacia Farnesiana.*
Khair	*Acacia Catechu.*
Kikar	*Acacia arabica.*
Kokko	*Albizzia lebbek.*
Kusum	*Schleichera trijuga.*
Litchi	*Nephelium litchi.*
Malhar	*Zizyphus Xylopyra.*
Marda Noyi	*Flemingia congesta var semialata.*
Nandu	*Cajanus indicus.*
Nyaung-gyat	*Ficus obtusifolia.*
Nyaung-gyin	*Ficus infectoria.*
Nyaung-peinne	*Ficus nervosa.*
Nyaung-thabye	*Ficus indica.*
Pakaur	*Ficus infectoria.*
Pakri	*Ficus infectoria.*
Palas	*Butea frondosa.*
Panjan	*Ougeinia dalbergioides.*
Paras	*Butea frondosa.*

Key to Vernacular Names of Lac host trees.—(Contd.).

Botanical Name.	Vernacular Name.
Pauk	... *Butea frondosa.*
Pauk-nwe ...	... *Butea superba.*
Petwun ...	... *Berrya amonilla.*
Pipal	... *Ficus religiosa.*
Plum	... *Zizyphus Jujuba.*
Prap	... *Ficus Rumphii.*
Putkul ...	... *Ficus glabella.*
Rain Tree ...	... *Pithecolobium Saman.*
Rarhar ...	... *Cajanus indicus.*
San-kanta ...	... *Acacia suma.*
Sha	... *Acacia Catechu.*
Sinthapan ...	... *Ficus Roxburghii.*
Shishum ...	... *Dalbergia latifolia.*
Siris	... *Albizzia lebbek.* / *Albizzia stipulata.*
Tamalan ...	... *Dalbergia Oliveri.*
Taung-Magyi ...	... *Albizzia odoratissima.*
Thadi ...	... *Bursera serrata.*
Thadut ...	... *Ficus Cunia.*
Thapan ...	... *Ficus glomerata.*
Thinbaw kokko ...	... *Pithecolobium Saman.*
Thitnu ...	... *Engelhardtia spicata.*
Thitya ...	... *Shorea obtusa.*
Tinsa ...	... *Ougeinia dalbergioides.*
Tur	... *Cajanus indicus.*
Wakgru ...	... *Engelhardtia spicata.*
Yindaik ...	... *Dalbergia cultrata.*
Zi	... *Zizyphus Jujuba.*

APPENDIX III.

Glossary of terms connected with Lac and the Shellac Industry used in this book.

Aghani.

Crop grown on Kusum or other hosts, using Kusum or progeny of Kusum brood. In Bihar June-July to January-February.

Alternation.

Cultivation of lac on two different host species for alternate crops.

Ari.

Lac cut from the tree before swarming, and containing living insects either mature or immature.

Artificial infection.

Usually referred to simply as infection or inoculation. The process of tying brood lac to the trees on which it is proposed to raise a lac crop.

Baisakhi.

Crop grown on hosts other than Kusum using brood other than Kusum or progeny of Kusum. In Bihar October-November to June-July.

Banch.

Bye product of the melting process, being residue left at the extreme end of the bag, it contains about 90% lac.

Bhatta.

Dutch oven shaped fire before which lac is melted in the cloth bag, during shellac manufacture.

Bhilwaya.

Man who spreads the molten lac on the porcelain cylinder, and stretches it into thin sheets.

Blocky Lac.

Lac which has set into a hard cake usually due to not being properly dried after cutting. Blocking more often occurs in ari lac than in phunki lac, and is caused by decomposition of the insect bodies.

Brood lac.

Mature lac in which the females are fully grown and are ready to give rise to their young. Brood lac is used to infect lac hosts with lac.

Button lac.

Lac which after the melting process of manufacture is dropped on to a zinc sheet and allowed to spread out into round discs about 3" in diameter and $\frac{1}{4}$" thick.

Cell (lac).

The coating of resin encrustation surrounding one single lac insect.

Chowrie.

Seedlac (also chaori and Saf chowrie).

Cheenty.

Lac left on the tree to swarm in situ.

Domes.

Excresences raised by *Eublemma amabilis* larvæ in lac.

Encrustation.

The resinous material secreted round their bodies by the lac insects, together with their exuviae.

Fine.

Superior grade of shellac usually made from Kusmi lac.

Garnet.

Dark coloured machine made lac, containing a large percentage of rosin.

Ghasander.

Man who stands in the washing vat and rubs the crushed lac against the sides with his feet.

Hari.

Name for Baisakhi crop, used in Punjab.

Host.

Tree plant or insect upon which a parasite or predator feeds, i.e., Lac host, any tree creeper or shrub on which the lac insect feeds and grows.

Infection.

Method of introducing lac on to the host tree on which it is to be grown, cf Artificial infection and Natural infection.

Inoculation.

See Infection.

Jethwi (Jethua).

Crop grown on Kusum or on other hosts using Kusum or progeny of Kusum brood. In Bihar January-February to June-July.

In Assam the winter crop. October-November to May-June, corresponding to the Baisakhi.

Karigar.

Man who carries out the melting of the Seedlac.

Katian.

Summer crop in Assam. May-June to October-November, corresponding to the Katki.

Katki.

Crop grown on trees other than Kusum using brood other than Kusum or progeny of Kusum. In Bihar June-July to October-November.

Kiri.

A bye product of the melting process, being the refuse left in the cloth bag, which is slit open at intervals to allow of its removal.

Kusmi.

Synonymous with Aghani. Here used to refer to lacs grown on Kusum or on other trees using Kusum or progeny of Kusum brood.

Lac.

General term embracing lac insects, encrustation and various products manufactured from the encrustation.

Laccifer lacca.

Scientific name of the lac insect.

Lactoras.

A class of people who cultivate lac in the Central Provinces.

Male emergence.

Emergence of male insects in the lac crop.

Molamma.

Finely divided dust like material separated from seedlac.

Nagoli.

Synonymous with Aghani.

Nand.

Vat in which the crushed lac is washed.

Natural infection.

Method of infection whereby a whole or a part of the mature lac crop is left on the host tree to swarm in situ.

Passewa.

Bye product obtained from the cloth bag used for melting after use, by boiling it in dilute soda solution.

Patti.

Bye product of the washing process.

Phirwava.

Boy who twists the end, away from the fire, of the cloth bag containing seedlac.

Phunki.

Lac from which larvae have swarmed and which consists only of the encrustation and the dead bodies of the female insects.

Raiyat.

Peasant.

Rangeen.

Synonymous with Katki. Here used to refer to Non-Kusmi lac, i.e. lac grown on hosts other than Kusum using brood other than Kusum or progeny of Kusum.

Scab lac.

Seedlac which has been heated on a hot plate and then pressed into little plates by hand. Some twenty years ago it was an article of sale in London, the port of origin being Karachi. Now-a-days due to the amount of dirt and insolubles, this commodity would have no sale. ((I should like to thank Mr. A. J. Gibson, Special Officer Lac Inquiry for this piece of information).

Scraped lac.

See stick lac.

Seed lac.

Stick lac after grinding and washing; may be called Chowrie.

Shellac.

The manufactured product prepared from lac after washing and melting, it takes the form of this yellow coloured flakes.

Standard I.

A grade of shellac, somewhat superior to T. N.

Stick lac.

Trade term for raw lac scraped from the stick, it may be either phunki or ari.

Superfine.

High grade shellac, generally made from Kusmi lac.

Swarming.

Emergence of the larvae from brood lac.

Test (Lac).

See Cell (lac).

T.N. Commonest grade of shellac manufactured, the quality is not high. The significance of the letters is unknown.

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16 chittacks = 1 Seer.
40 Seers = 1 Maund = 82 lbs.

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